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ENGINEERING RESEARCH AS AN AID TO GOOD TEACHING.

BY A. A. POTTER,

President of the S. P. E. E. and Dean of Engineering at Purdue University.

Teaching is the first and most important function of an engineering college, but to be most effective it should be supplemented by research. To develop engineers who have initiative, the power to lead, to plan, to originate, and the capacity to apply—we cannot limit our instruction to the past, but we must place our students in contact with teachers and with research workers who are interested in exploring new fields, in trying new experiments and in advancing engineering knowledge.

Engineering is a profession of progress. Research, or the creation of new knowledge, is the foundation of engineering progress. The field of engineering knowledge will not be advanced by the engineer in practice any more than is medicine by the average practicing physician. The engineer in practice makes use of knowledge which exists; new knowledge must be systematically sought.

The complexity of modern engineering practice requires a constant supply of new knowledge. To meet this need industrial research laboratories have been developed in connection with the electrical, chemical, and metallurgical industries. The research departments of the public utilities and the technical bureaus of Government departments are also constantly adding to engineering knowledge. These agencies, however, cannot continue to advance knowledge unless the engineering colleges are in a position to train men who have the preparation, the ability and the desire to carry on investigations, and to make new discoveries through research. Research laboratories in connection with engineering colleges, besides train-

ing research workers for the industries, the utilities, and the Government, have advantages as compared with other research agencies on account of the greater freedom from interruptions, an atmosphere which is sympathetic to research, and because of the fact that results need not be safeguarded by secrecy.

To what extent are the engineering colleges engaged in engineering research? In the United States of America nearly three fourths of a million dollars are being spent annually for research in about thirty engineering colleges. The colleges have organized research departments or Engineering Experiment Stations. The Division of Industrial Coöperation and Research of the Massachusetts Institute of Technology and the Engineering Experiment Station of the University of Illinois are each spending annually over $150,000.00. The Iowa State College Engineering Experiment Station spends over $75,000.00 annually and other institutions have annual budgets for engineering research which vary from $250.00 to $45,000.00. The Engineering Experiment Stations of the University of Illinois and of the Iowa State College have been operating for over 20 years and have published to date over 225 bulletins. The majority of the other engineering college research departments were established fairly recently but all are of value to the manufacturing and utility interests of the country, are useful in developing the resources of the different states, are popularizing engineering research, are training research workers and are reacting beneficially to engineering instruction.

Many engineering problems are awaiting solution and we engineering teachers are neglecting our opportunities if we do not carry on some investigations along our own specialty. In most cases such work, on account of the lack of funds, must be carried on in a small way, but each of us can do something toward the extension of the boundaries of engineering knowledge. The best way to secure support for organized research is for every engineering college to undertake some investigations of value to the public. In most cases small sums from the engineering college budget can be found for special

equipment or for research assistants. As the work grows in importance adequate support is bound to come either from public funds or from private benefactions. The Chas. A. Coffin Foundation awards annually five thousand dollars for research fellowships. Some of the younger engineering teachers who are interested in research should take advantage of this opportunity to continue their preparation. Several engineering colleges have succeeded in interesting manufacturers and utilities in contributing fairly large sums for engineering research. Our duty and our responsibility are pointing out to the authorities of our colleges as well as to leaders in engineering and in industry the importance of encouraging research in engineering colleges from the standpoint of more efficient engineering instruction as well as for the purpose of insuring continuous advancement of industry. The research organizations are confronted with an inadequate supply of properly trained men to carry on high grade scientific and engineering investigations. The thousands of students who are enrolled in our engineering colleges include some who should be encouraged to prepare themselves for engineering research as a career. We must leave no stone unturned to provide on outlet for those of our students who show that they have an element of originality, a spirit of adventure and courage to prepare themselves for a research career. Greater activity in research on the part of engineering colleges will stimulate better teaching, will aid in laying the proper foundation for the future growth of the engineering profession, will develop the proper type of graduate instruction in engineering, and will train engineers who are leaders in extending the borders of engineering knowledge.

A NEWS LETTER FROM PARIS.

BY W. E. WICKENDEN,
Director of Investigation.

The study of engineering education in Europe which forms one of the principal divisions of the Society's general investigation was begun early in January. What benefits were to be sought from this study were not wholly clear at the start and possibly are not yet fully revealed. As in the work at home, objectives have to be formulated as we go. We may expect to find many things done better than we do them, which we may copy or borrow to our profit. More important, perhaps, is the gaining of an adequate background for that inevitable appraisal and criticism of the work of our American schools to which the studies of the coöperating committees are leading us.

A few lines will suffice to sketch the progress of the work. Thus far the writer has been in direct touch with the work of the schools only in France and Belgium. Visits have been made to fourteen schools in Paris, to three in the north of France and to five in Belgium. In both of these countries officers of government and industry, as well as educators in various fields, have been interviewed and the sources of printed information quite fully canvassed. Brief visits to Germany and Switzerland have afforded some exceptionally valuable contacts and have greatly facilitated the plans for future work. A month to be devoted to Great Britain will include attendance as a fraternal delegate at the annual meeting of the British Association of Technical Institutions in March, where the writer will present a brief paper on the Society's general investigation. A preliminary program for work in Italy has been laid out with the admirable assistance of Dr. Luiggi, a leading figure in Italian engineering circles, who became interested in the Society's work during his visit

to America last autumn. In addition to the countries already named, the work will extend to Holland, Austria, Czechoslovakia and probably one of the Scandinavian countries.

As the studies have not been completed in ony of the above countries, only general impressions can be sketched at the moment and in only the roughest outline. What follows relates principally to France and more particularly to Paris. There complete courtesy and consideration are met on every hand, but the slight indications of a reciprocal interest are in marked contrast with the evidences of such interest in Belgium and Germany. The numerous engineering schools of Paris are quite independent of the university and each is devoted to a particular sphere of engineering. Three of them are attached to the Ministry of Public Instruction, two to the Ministry of Public Works, and one each to the Ministries of Commerce, War and Marine. One is municipal and one, the *Ecole Supèrieure d'Electricité,* is an adjunct to the French Society of Electrical Engineers. Others are quite independent and even proprietary. In Lille, Lyon and Marseilles there are important schools fostered by the respective chambers of commerce, but having working relations with the national universities in those cities, while at Caen, Grenoble, Lille, Nancy, Strasbourg and Toulouse there are strong technical institutes within the universities themselves.

France remains, as ever, the world's great exemplar of individualism in all things intellectual and of centralization in all things governmental. These traits, together with the complex scheme of organization of higher technical education, weaken the impulse toward voluntary coöperation among the schools and toward reciprocity in a coöperative undertaking such as ours.

While is must be recognized that higher education in France is laboring under great financial and material handicaps, the French appear to have few if any misgivings as to its fundamental soundness and effectiveness. They are proud of their educational record and are not seeking to borrow from the methods of other nations. The Belgians, however, less orig-

inal and more adaptive, have sought and are seeking far afield for the models of their technical education, so that an American finds them kindred spirits. The Germans, too, viewing with admiration the vast industrial and material prosperity of America, are inclined to associate them with certain features of our educational system of which they are eager to learn.

The American who seeks to understand and appraise French technical education in a short period has still other difficulties to overcome. The teaching personnel of the French schools is not easy of access. Professors are of two general types, one consisting of prominent industrialists or government functionaries who are not teachers by career, but who perform their limited teaching duties with great fideliity and distinction, and the other savants from the universities who often hold chairs in several institutions simultaneously and are engaged in active programs of research. Such men are naturally preoccupied and lack the collective consciousness of an American faculty. Furthermore a speaking knowledge of English is uncommon among them, and no interpreter is able to lay bare the richer sub-strata of experience and reflection to which the inquirer seeks access. Statistical records are rarely kept and are hard to get, while in many institutions it is a fixed rule to allow no visitors in the principal class and laboratory exercises.

However, many of the principal characteristics can be briefly sketched:

1. *Specialization.*—The schools are specialized according to the broader divisions of engineering, such as manufactures, electrical technology, transport and structures, the mineral industries, and the like, but the curricula are notably strong on the theoretical side and broad on the technical side. Special emphasis is given to "complementary" programs of one year, intended for graduates who wish to specialize.

2. *Teaching Personnel.*—Notable university professors for theoretical courses and distinguished engineers for technical courses, with full-time, competent *"chefs de travaux"* for laboratory instruction are the almost uniform rule. The rel-

atively small student bodies (100 to 750) make a fairly intimate contact possible. Recruitment does not appear to be a serious problem.

3. *Student Personnel.*—In the Paris schools numbers are strictly limited and the methods of admission are highly selective and there are practically no eliminations in course. In the provincial institutes the initial selection is less strict and eliminations more numerous. The competitive admission examination, known as a *"concours"* is far more formidable than any corresponding examination in America. It is usually given in two parts, the first written and the second oral and occupies in all from one to two weeks of time. From one-sixth to one-third of the candidates are successful, but many take an additional year of preparation and try again. From the viewpoint of scholastic excellence and homogeneity five or six of the Paris schools probably have the most elite student bodies in the world. Beneath this highly selective system of admission is an admirable foundation of secondary education, uniform throughout the country, notably thorough and coherent, with a male teaching personnel of remarkable devotion and ability. The French engineering student has a cultural foundation and an intellectual formation which embody the traditions of centuries. He knows his mother tongue and his basic mathematics as few, if any, American freshmen. He is accustomed to hard work and accepts the rigorous regime of an engineering school as a matter of course. He does not need to be coaxed to learn and he has no illusions about the intensely competitive conditions which await him in the economic world.

4. *Discipline and Student Life.*—The discipline of all French technical schools is strict. Perfect regularity of attendance and punctuality of performance are insisted upon, in complete contrast to the academic departments of the universities. The student bodies are wholly unorganized and have no group life. Their recreations are wholly individual —perhaps excessively so. They plainly show the marks of hard and confining work. At no time do they experience

such adventures of self-discovery and self-expression or gain the training in voluntary coöperation which go with the multifarious "activities" of an American school. No doubt they read more widely and more solidly and cultivate a much more æsthetic taste than the typical American student.

5. *Instruction and Examinations.*—Oral instruction is given to large groups in theoretical and technical subjects. These lectures have a finish and distinction little known in America. Each student usually undergoes an individual oral examination in one subject each week and there are numerous exercises ranging from simple problems to very elaborate engineering projects, on which he is carefully graded. The methods of laboratory teaching correspond very closely to those in America. The training in design is particularly thorough, reflecting the national sense of form and the excellent preparation given in the secondary schools. Final examinations are also given, and the record of each year is computed by combining the entire group of individual items referred to.

6. *Equipment.*—The scientific equipment for physics, chemistry and geology is usually excellent and abundant. Special engineering equipment such as engines, boilers, hydraulic machinery, testing machines, ore dressing equipment and metallurgical equipment of industrial type is not as abundant as in an American laboratory. The technical schools of middle grade (*Arts et Metiers*) have shops of exceptional completeness, but those in the higher schools are quite modest in comparison. In general the higher schools have consistently avoided all effort to simulate industrial conditions. In many cases the collections of mechanical and structural models are exceptionally good.

7. *Miscellaneous.*—Low salaries and limited equipment of the heavy type, together with the high proportion of lecture instruction, keep costs low. "We pay in honor," said one director in referring to his salary budget, wherein the regular salary of a professor appears as 3,000 francs (approximately $160) per year. In general, the system has the characteristic virtues and defects of educational aristocracy. The

recruitment of all the higher technical functions of the state and of certain industries such as transportation, through a limited group of schools with the military *Ecole Polytechnique* as an introductory stage, constitutes a vested interest which limits the free development of higher education. Contact with industry and with engineering service is maintained through the practical activities of professors, and through the advisory committees which pass upon the curricula and general plan of instruction of the schools. Only a limited amount of industrial research is done in the schools. While more than half of the universities maintain institutes of chemistry for the training of industrial chemists, there is nothing corresponding closely to the American curricula in chemical or ceramic engineering. Agricultural engineering, however, is taught in one or two institutions. The majority of schools require their students to complete one or more probationary periods in industry or in active engineering service. Under the present law, engineering students receive supplementary military training one afternoon each week, and are required to do one year of special service as junior officers. Thereafter they are ranked as reserve officers of the engineers, artillery or other technical arms of the service.

While France is making a great effort toward industrial recovery, there is little evidence of a concerted program of industrial aggrandizement on a large scale, such as would involve a great expansion of her system of technical education. Expansion is being pushed at the bottom of the scale in schools of apprenticeship for skilled workers. France apparently prefers to remain France, a land where individual attainment and development are highly fostered, rather than to give herself over to a modern program of mass organization for mass production.

NOTES ON ENGINEERING EDUCATION IN GREAT BRITAIN.

BY W. E. WICKENDEN,

Director of Investigation.

Great Britain and France afford the student of engineering education a series of interesting contrasts. France began as early as 1760 to provide an engineering training of a formal type, limited to a chosen elite, so that the engineer's profession has been from the first one of high prestige, largely dominated by men trained in the *grandes écoles* of Paris. It has been a profession of the black coat and the white collar, one of the strongholds of the *haute bourgeoisie,* clearly set off from the manual crafts. The British tradition, on the contrary, is that the engineer is primarily the product of the shop, the mine, the mill or the works of civil construction, who by native ability and perseverance has finally arrived at some knowledge of the science of his craft. In Britain the term "engineering" is used interchangeably for a trade or a profession, with a strong suggestion of practicality. French engineering began by being ultra-scientific and is tending toward practicality, while British engineering is beginning to discover and adopt the man of research.

While French engineers have taken a dominant place in the administration of transportation, mineral and manufacturing industries, their British confreres have kept more closely to the purely technical functions. The French engineer is also a far more important factor in government administration, but the profession has had little part in the legislative side of either country.

The professional training of engineers has only recently come to be regarded as one of the normal functions of a university in both countries. In the Napoleonic era the universities of France were reduced to practical impotence and the

number of separate specialized schools greatly increased. In the past fifty years the universities have been reconstituted and recently have been giving increased attention to technical education, but they are still overshadowed by the specialized schools. The older universities of Great Britain were long dominated by conservative traditions unfriendly to the applied sciences. There grew up a great number of local technical schools, primarily engaged in the part-time education of men employed in the industries, although some extended their work to substantial university rank. In recent years there has arisen a group of modern universities, principally in the great industrial centers, where the applied sciences have found a thoroughly congenial home. The older universities, especially Cambridge, have felt the urge of the times and have fallen into line.

There are virtually no engineering degrees in France, but each school grants its own professional diploma with whatever prestige it commands. In many cases these diplomas are signed by the Minister of Public Instruction and have a quasi-legal status. No British university grants such professional degrees as C.E., M.E., E.E., etc.—in fact the mere idea of a university conferring such a professional title would probably seem preposterous. Practically all the British universities now grant the B.S. in engineering, though Cambridge adheres to the time-honored B.A. and groups its technical studies under the title of "mechanical science." British universities award the M.S. and the Ph.D. for advanced work in engineering. French universities are now authorized to confer the doctorate for advanced engineering research.

To an American observer the most striking feature of British technical education, and perhaps the most admirable, is its great flexibility. Provision is made for men of almost every type and of every grade of ability and preparation. The way to the B.S. degree is open to every man who can qualify for it, either as an "internal" student in a degree-granting university or as an "external" student in any other

institution preparing for the external examinations of the University of London. An admirable system of "national diplomas" and "national certificates" has been inaugurated by the Institutions of Mechanical Engineers and Electrical Engineers, in conjunction with the national educational authorities and the numerous technical schools, to give substantial recognition to non-degree courses. The "diplomas" are of higher rank than the "certificates" and have a prestige in the eyes of employers little if any lower than a university degree.

A particularly interesting plan has been worked out in Scotland whereby the Royal Technical College in Glasgow and the Heriot-Watt College in Edinburgh, both of which are affiliated with the respective local universities, also serve as "central institutions" to the local technical schools in the adjacent counties. The local schools are principally evening and part-time schools for employed men and boys. When a student reaches the upper limit of the local school he is given financial assistance by the education authorities which enables him to continue his studies in the "central institution." The student may then advance by evening studies to a national certificate or diploma. If he meets the matriculation standard he may prepare thus for the external degree of the University of London. If he shows unusual promise he may be recommended to the education authorities for a bursary and be transferred to the full-time day course for a diploma or a degree.

Practically all the universities have three classes of students, candidates respectively for the degree with honours, the ordinary degree or a diploma. All degree men must be matriculated, either by examination or other equivalent proofs of attainment in English, a second language, mathematics and elementary science. Diploma men are required to satisfy the authorities of their ability to carry the work with success. In every case the degree with honours calls for a higher standard of mathematical and theoretical attainment than the ordinary degree, although the specific requirements vary greatly.

In some institutions the honours degree is given for distinction in the final examinations, in others additional work is required in the regular course, while in others an extra year is given to special work. Diploma men usually take the same courses as degree men.

Except at Glasgow the normal full-time courses for the degree cover three years of eight to nine months' work. At Glasgow there are four years of seven months each. Sheffield offers the option between such a four-year course and the regular three-year course. The curricula are wholly scientific and technical, the foundation of general and cultural studies being left wholly to the secondary schools. The curricula are relatively simple in structure and emphasize the fundamentals common to engineering, mathematics, physics, chemistry, mechanics, hydraulics, thermodynamics, electrostatics and dynamics, drawing and tool operations. These subjects are all treated from a technical viewpoint, but no pretense is made of an extended study of engineering applications in the three-year period. An optional fourth year is provided for men who wish to specialize in engineering applications or who wish to undertake some research problem.

The British engineering student is a hard worker. His prescribed work in the lecture rooms, drawing offices, shops and laboratories occupies from twenty-eight to thirty-five hours per week. It is difficult to reduce this program to an equivalent in American credit hours, but it would appear to range from eighteen to twenty-two such units. In the shop and laboratory work the student is directed much as the American student, but in the class-room subjects he is left much more to his own responsibility. The subjects are developed in some detail in lectures and tutorial conferences, the student is introduced to the literature of the subject, is given a fair number of exercises to work, and is then left to his own devices. His secondary education has prepared him for such a degree of self-directed work and he does it rather more thoroughly than the much supervised American student who is fed on a text-book diet.

On paper the requirements set for the bachelor's degree would appear to be a set of examinations to be passed, rather than a curriculum to be accomplished. The fact is that it is both. The student groups are small—one hundred and fifty is a representative number—the association with the teachers is intimate and no student is allowed to fall behind in his work. It is not so much a matter of police regulations as of tradition and comradeship. Engineering teachers in Great Britain look askance at our great student groups and the complex machinery of administration in our schools and pray to be spared from all such "factory methods."

Engineering education in British universities is an expensive business. The equipment is large in proportion to the number of students. The same is true of the teaching staff. The teachers are well paid. As they receive in actual currency the practical equivalent of American teachers, their relative compensation is considerably greater. British universities are taxed on their property values. The money outlay per student is considerably above the American average. It is to the credit of the British educators that they have not yielded to the temptation to expansion as a means of reducing unit costs.

University teachers in Britain are teachers by career. The supplementary earnings from engineering practice are quite small and come only to a few outstanding men. There are few opportunities for remunerative employment in vacation periods. For contact with industry and advances in practice the chief reliance is placed on research and on active service on the committees and commissions of the national institutions of engineers. Teaching loads are practically identical with those in the stronger American schools. Turnover among teaching forces is small and advancement comes slowly.

The outstanding features of British engineering education appear to be flexibility, fair equalization of recognition for degree and non-degree courses, intimacy of contact between teacher and student, simplicity and solidity of curricula, high

costs and high fees, thoroughness in the teaching of fundamentals, the absence of cultural training, the insistence that university work must be supplemented by a long apprenticeship in practice and the rapid development of research as a contribution to knowledge and to the solution of the economic crisis of the nation.

UNION COLLEGE.

BY CHARLES N. WALDRON,
Secretary, Graduate Council.

The movement seeking to establish a college in Schenectady began during the American Revolution. In fact, a petition to this end was presented to the state assembly the year of the battle of Saratoga. It was not, however, until February 25, 1795, that the wishes of the petitioners were granted and the then frontiersmen living in the lower Mohawk Valley saw the academy they had established in 1783 elevated to college rank.

There is much that is unique in the early history of Union College. It came into being—not through the efforts of a church or even of a wealthy individual but as a popular movement; something over three thousand names appearing on the petition for its charter. The same is true of its financing which was made possible by many small gifts. In short, it represented a truly democratic movement, quite in keeping with its location on the frontier and the spirit which was soon to produce the party of Thomas Jefferson and give force to American democracy.

Its founding was unusual in another respect. All the Protestant denominations, which by the way represented all the churches in the vicinity, united in its establishment. This led to the choice of "Union" as the name of the new college and made it the first non-sectarian college in the country.

A democratic and liberal spirit marked its history from the beginning. Under the lead of its great president, Eliphalet Nott, (1804–1866) it became a pioneer in educational reform. He sympathized with the movement already begun at Union to liberalize the curriculum. In 1803 French was offered as an alternative for Greek both as an entrance requirement and in the college curriculum. Dr. Nott recognized that the coun-

try needed technically trained men. He brought Ferdinand R. Hassler from West Point to Union as professor of mathematics in 1810. Hassler made a beginning on what might have developed into a definite engineering course, for he offered in that year courses in surveying and geodesy but he left soon to take charge of the United States Coast Survey and so the matter dropped. But as early as 1820 Dr. Nott established a scientific course and in 1845 a course in Civil Engineering. This course was organized and directed by Professor William M. Gillespie from the date given until his death in 1868. Professor Gillespie was succeeded by Dr. Cady Staley, who directed the course until 1887 when he went to Cleveland to become president of the Case School of Applied Science. Work in science was made more technical in 1855 when Charles A. Joy, freshly returned from his studies in Germany, was asked to establish a department of chemistry. Joy left in 1858 to help organize the Columbia School of Mines and was succeeded by Charles F. Chandler who, in the next eight years, gave the department a character and vigor which is not forgotten even to-day.

Dr. Nott's ideas of discipline were even more progressive than his ideas about the courses of study a college should offer. All he asked of a boy was that he "behave as a gentleman." This was looked upon by most educators as sheer madness and brought both the president and the college much adverse criticism, a thing hard to understand to-day unless perchance one reads the elaborate rules of conduct current in the American colleges in the early part of the last century. A boy, expelled from another college for infringements of rules the president held to be unimportant, was admitted to Union and given a new chance. Such liberality led his critics to speak of the college as "Botany Bay." Time, of course, has justified his methods and his ideas of discipline are now accepted everywhere.

Perhaps the most striking of his innovations was the encouragement of college fraternities, which were banned elsewhere. As a result, Union became the mother of our frater-

UNION COLLEGE, SCHENECTADY, NEW YORK.
John Howard Payne Gateway with memorial library in distance.

nity system. The first of these, Kappa Alpha, being founded in 1825, followed by Sigma Phi and Delta Phi in 1827, Psi Upsilon in '33, Chi Psi in '41, and Theta Delta Chi in '47.

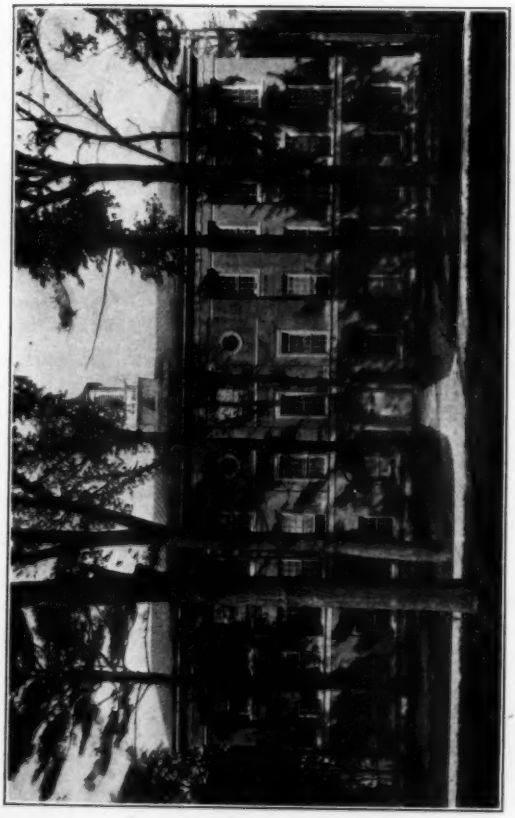
UNION COLLEGE, SCHENECTADY, NEW YORK.
General engineering building with old South College beyond.

There must have been something very stimulating about Dr. Nott's educational methods, for during his long administration the college graduated a very remarkable group of men. In the field of education, particularly, his "boys" stand out, some ninety of them becoming presidents of colleges, which list includes Augustus W. Coles, who was the first president of Elmira, which in turn was the first of the women's colleges in this country. In this same field should be mentioned John H. Raymond, first president of Vassar, and L. Clark Seelye,

first president of Smith. An even more important educational service was that of Henry P. Tappan, first president of the University of Michigan and the organizer of our state university system. Dr. Nott's most distinguished pupil was Francis Wayland, who is perhaps an even better known figure in the history of American education than his preceptor. Nor was the educational work of Nott's "boys" confined to this country alone, for one of them, David Murray, organized the first school system in Japan.

Dr. Nott's great error was to keep all authority in his own hands and rely entirely on his own efforts. As he grew old, the college grew feeble and, at his death, after a service of sixty-two years, he left Union in no condition to meet the competition which younger and better-organized institutions offered. Dissensions in the faculty spread to the trustees and to the alumni body and it was only towards the end of the century, with the inauguration of the Rev. Andrew V. V. Raymond as president in 1894, that this unhappy period closed.

It takes much to kill an institution with so great a past and so noble a tradition as Union had made for herself. The return to strength, which set in at this point, was rapid. Dr. Raymond was a graduate of the college and familiar with its spirit. He appreciated the opportunity for electrical study which the development of the General Electric Company's great plant in Schenectady made possible. He added a course in electrical science to the curriculum in 1895 and, thanks to the generous coöperation of the Company, it has been a striking success. Old quarrels were healed and the finances of the college, which were in a deplorable condition, were straightened out. President Raymond resigned in 1907, turning over to his successor an institution free from debt, and with an alumni body whose faith had been renewed in its future. The administration of Charles Alexander Richmond, his successor, began in 1909 and under his very able leadership the college has had a phenomenal development. The student body has increased from less than three hundred to more



UNION COLLEGE, SCHENECTADY, NEW YORK.
Butterfield Chemical Laboratory.

than seven hundred, the endowment from less than half a million to three million, and the faculty from twenty-four to sixty-five. In addition to all this, over eight hundred thousand dollars has been spent on the campus in the shape of buildings and equipment. The college today is equipped to do unusually good work in such scientific fields as electrical engineering, chemistry and physics, due to its unique environment, but it has always preserved its academic tradition and half its students are candidates for the bachelor of arts degree. Even its technical courses give much time to academic work. It is interesting to note in this connection that our best known professor, the late Charles P. Steinmetz, was a strong believer in the wisdom of making academic subjects, even Greek, part of an engineer's training.

The campus occupies sixty-four acres of land, lying at the crest of a hill in the center of Schenectady. Rows of tall elms set off its paths and roadways. The gray stuccoed walls of its old buildings, erected in 1814 and designed by a French artillery officer, Jacques Ramee, strongly suggest monasteries of southern France and give it a character to be found in no other American college. Unused portions of the campus are still covered by a native forest and in the heart of this lies a garden of six acres. A ravine, cut by a brook, is one of the attractive features of the garden, which has been developed along natural rather than artificial lines. This garden is the show place of the town, and to see the natural amphitheatre it contains, filled with the gayly dressed Commencement crowd which gathers there for Class Day exercises, is an experience not soon forgotten. Few colleges have been gifted by nature with such a beautiful setting.

SCIENTIFIC METHODS IN THE TRAINING OF ENGINEERS.

BY HORACE B. ENGLISH,

Antioch College.

Two processes, Merz tells us in his "History of European Thought," have helped to determine the intellectual progress of mankind: the extension of knowledge, and its condensation. We have begun in the last few years to realize with a new keenness that the command of knowledge is as important as its accumulation. Hence there has sprung up in our colleges a number and variety of "survey" courses by means of which the student is enabled to overlook a wide landscape from an elevated point of view. With this tendency of collegiate education the writer is in the fullest sympathy. But we are in danger of forgetting the peculiar and seductive nature of these commanding prospects. We are apt to forget that "there is scarcely anything so ephemeral as scientific theory." We shall fail truly to represent the spirit of modern science, which we profess to be so concerned to impart, if we do not impress upon our students the fact that we have science not so much when we search for, or attain, "true theories" or facts as when we proceed by certain methods.

Moreover, especially in engineering, we tend to neglect the training of those who must carry forward the exploration of regions still unmapped. There is as much need for research and the research spirit in engineering as in chemistry or in botany; yet research workers in these fields are proportionately perhaps ten times more numerous. Progress in engineering, if one who is not an engineer may hazard an opinion, does not depend merely upon research in pure physics and the other natural sciences; it depends yet more vitally upon engineers who will give trained talents to research or

who will carry the research spirit and the scientific methods which research demands into the field of practical application.

So much will probably be granted without discussion. The most advantageous method of teaching these methods of scientific inquiry is another matter. The traditional view is that they must be learned as most scientists have in fact learned them, by patient practise in actual investigation. If this be so, then a definite and narrow limit is placed upon the application of scientific methods by the average citizen or even the average college graduate. Let the scientifically trained reader look back upon his own mental development. He will realize, I think, that it was not until he began graduate work that the essentials of scientific attitude and technique began to be of real service.

The reason for this is not far to seek. We have said that scientific theory and fact are ephemeral; a more accurate statement would be that they are transitional. It follows that we cannot neglect them in either our thinking or our teaching. Indeed in teaching a science there is an enormous body of fact and theory which must be imparted. It is upon this that most of the time must be spent. Or rather upon this and upon the still more preliminary task of inculcating a new vocabulary. It is small wonder, then, that the teacher struggling with the all but impossible task of getting his students to see what the facts are has little time to show how they were obtained or what his assurance is that they are facts. If he can get them to understand what he is talking about and why it is important, he may well feel pleased.

I do not mean to imply that any teacher of a natural science would to-day teach it dogmatically and deductively or that experimental evidence is neglected. I do mean that the scientific methods are so embodied in the concrete details of the experiment (as is perfectly proper they should be) that the student gets but a "worm's-eye view" of them. The instructor has seldom time to abstract these methods for his students from the welter of concrete particulars and thus to present the general principles of procedure. Yet there would

seem to be the very greatest advantage in disentangling the essential methods in use from the mass of their concrete application and thus getting a bird's eye view. Here as elsewhere advance may come from a clear statement of what has long been intuitively known. All the facts, for example, needed for the formulation of the law of the equality of pressure and counter-pressure in fluids were in some fashion empirically known before Newton's day. Yet his clear statement of that principle put the science of mechanics upon a new level and enabled the discovery of important new applications.

It would undoubtedly be more tactful to leave the justification of a distinct course in scientific methods at this point. Yet to do so would be to leave out what the writer believes to be one of the main reasons for giving it. We must admit that outside the limits of their specialty, scientists are not particularly noted for the critical character of their thinking. To give examples would be invidious and unnecessary; all of us can think of eminent scientists who have made deplorable spectacles of themselves when they have wandered a little too far afield. One reason is that, as John Dewey points out, so much of the work in science is hardly more than technical manipulation which results by itself only in specialized habits of thought. These, while they may be effective in limited fields, do not apply (or are not seen to apply) to the larger problems and issues of life. Yet this is just one of the crying needs of the age. We need to learn to take a more "matter of fact attitude towards even those things which are not yet matters of fact" and this is notoriously difficult. For our prejudices are commonly enlisted in inverse ratio to the accumulation of fact concerning the matter at issue.

We need, as James wrote as long ago as 1876, to "attack things as if there were no official answer preoccupying the field. . . . The best use of our colleges is to give young men a wider openness of mind and a more flexible way of thinking than an special technical training can generate. . . . (We should

cultivate) the habit of always seeing an alternative, of not taking the usual for granted, of making conventionalities fluid again, of imagining foreign states of mind. In a word it means the possession of mental perspective."

Both James and Dewey seem to argue from this the need for a study of the humanities and the social sciences. But a too exclusive devotion to the humanities tends to set up in the student the antiquated dialectic and argumentative approach to the solution of problems. This has still its value; neither economics nor psychology, for example, has been able yet to free itself fully from this method—indeed it lingers on to quite a surprizing extent in many of the discussions in physics and chemistry. But although I do not wish to minimize the necessity of such method, it is clear that the great advances in human knowledge have come and have come most rapidly in proportion as men have freed themselves from the intellectual gymnastics of philosophical speculation and have applied the methods of empirical science. In justice to philosophy, we must note how large a part philosophy has played in promoting just this empirical frame of mind. Nor need the implication be taken that there is not a genuine field in which the philosopher must exercise his art.

The general procedure in our course at Antioch has therefore been somewhat as follows. Beginning with a study of the methods actually and profitably used in the sciences, we turn to everyday life and the social sciences for most of our examples of error. We show the error to be due to the failure to use proper scientific methods and how the use of these methods would have secured the avoidance of the error. Class exercises are assigned in which the student is asked to solve some problem of live interest and concern by the use of the methods under discussion. Thus during the past year the question of the value of intercollegiate athletics having been raised by a small group of students, the class was required to make a scientific analysis of the problem instead of wasting energy in personal recrimination against opponents. In this

fashion the various phases of scientific method are brought out by their application to the most diverse fields of human interest, the ground cleared for the transfer of the fruitful modes of attack from one field to another, and a beginning is made of making such modes of attack to any sort of problem whatever habitual. The continuance of such a habit depends of course in part upon the student and in part upon his instructors in the natural and social sciences.

It must be added that we do not imagine that the scientific method is all of life. There are times when we must realize the limitations of analysis and see that we cannot by logical processes bring into a complicated case more than a few of the factors involved in actual accomplishment. Synthetic and summarizing imagination, the lack of which a distinguished engineer finds to be the most common failing in his profession, cannot to any large degree be taught. Analysis can be carried so far that it consumes too much attention and causes us to lose perspective. Not infrequently, especially in making general plans, it pays us to leave detailed analysis alone and to trust to intuition.

Yet there is here no opposition but only supplementation. "The greatest minds are at the same time the most logical and the most intuitive. . . . The more there is to a person, the more will there be of him at each of these levels." Intuition does not work in a mental vacuum. An enormous number of the greatest inventions and discoveries have come in a flash of insight concerning which psychology can tell us little. But these flashes of insight have sprung up from a fertile and intensively cultivated field. With few exceptions, the great intuitions in mathematics have been granted only to mathematicians, in physics to physicists, in geology to geologists. The electric collision and synthesis of ideas which we call insight frequently follows a period of rest and withdrawal from the problem; but that period of rest in its turn follows a period of the most intense and preoccupied study. And in this preliminary period the most intuitive genius needs the guidance, consciously or unconsciously, of the scientific methods.

WHAT IS WRONG WITH TECHNICAL EDUCATION.*

BY C. R. FORBES,

Head, Mining Department, Missouri School of Mines.

"The question, 'What is Wrong With Technical Education?'" seems to be a burning one at this time. These words are written not with the idea of trying to answer this question, but simply to suggest some of the possibilities.

The chief indictment against technical education seems to be that graduates of technical schools are not filling as many positions of responsibility as they should. We might perhaps change this to say that technical graduates are not making enough money. Unfortunately actual figures are lacking to prove this contention. The National Industrial Conference Board is conducting a survey to cast some light on this subject. According to the *E. & M. J.* of November 22, their findings for two industries were as follows: In the rubber industries, out of 100,000 employees only 7 per cent. hold important positions. Of this 7 per cent. 23 per cent. are classified as college graduates. In the paper and pulp industry out of 35,000 persons employed, 7 per cent. had executive positions. Of this 7 per cent., 22 per cent. were college graduates, 13 per cent. from technical schools.

Certainly these figures do not show that a college education is necessary to obtain a high position in industry. However, the figures are not conclusive and to prove anything should include the total number of college graduates employed. If 10 per cent. of the employees are college graduates and the college graduates occupy 23 per cent. of the real jobs it would appear that by going to college a man would increase his chances 2 to 1 for obtaining executive positions in these industries. I have no idea what percentage of all employees

* Paper presented at Meeting of Committee on Engineering Education.

were college graduates and without knowing it the figures have little value.

In the mining industry we are told that out of 40,000 mines in this country not over 10 per cent. are in *complete* control of graduate mining engineers. It is said that lawyers, doctors and merchants are occupying positions that should be held by engineering graduates. These figures are no doubt true. However, I feel quite sure that if the figures were restricted to the larger mines, especially metal mines, that it would not be quite so one-sided. In considering a single district like the Michigan Copper District, we will note that the executive jobs are largely held by mining school graduates. The same is true in southeast Missouri. If, however, we insist that graduates of mining schools should be in complete control we must find them lacking. This involves usually financial control and the accumulation of considerable wealth before such control is gained.

Assuming that our technical graduates are not filling their proper sphere, where is the trouble? And how can it be corrected? The chief point of attack just now seems to be the curriculum, perhaps because that is the easiest thing to change. We are told that our graduates are not men of vision, cannot handle labor properly, know nothing of business, etc., etc. And it is proposed to include certain subjects in the curriculum to remedy these defects. This would indeed be an easy solution, but on mature reflection does anyone claim that this is possible? That by merely changing the course of study a little we can change the character of our graduates.

The college that can offer a course that will actually produce executives, men of keen judgment, business men, leaders, men of broad vision will be crowded to overflowing in a very short time. No, this is not the answer; perhaps the present courses of study are not perfect, but it makes little difference what changes are made. Given the same raw material in the form of students, the same faculty and the same methods of teaching, the same outside influences or environment, and the

finished product will be almost exactly the same no matter what the course of study.

However, in a technical school the course must obviously be largely technical; otherwise it approaches the A.B. courses. As to which kind of course is the best training for a young man, I hesitate to say and I am assuming that technical education is necessary.

According to T. A. Rickard the purpose of an education is to teach one to think clearly, observe accurately and state truthfully. He states that it makes little difference what courses are studied—but that the manner of learning is the essential thing.

By this line of reasoning we are brought to this conclusion concerning mining education: A mining engineer should study the various sciences including mathematics, physics, chemistry, etc., in order that he may apply them as occasion arises to improving the art of mining. He should be well versed in English in order to be able to present his ideas to others. He should be an accurate observer.

I believe that no one will question that a study of the sciences above mentioned is more conducive to exact thinking than a study of sociology, history, religion. True these other subjects present questions that give opportunity for endless thinking and that is exactly their trouble. They do not arrive at definite conclusions.

Our present curriculum is arranged very largely with this in mind. The first two years are devoted almost exclusively to the fundamental sciences. In the last two years, we have certain applied courses including in the junior year, mine surveying, junior mining and assaying. If these courses do not aid the student in helping to develop his thinking ability and powers of observation, they should be thrown out to make room for some that will. If on the other hand, these courses do assist in developing these qualities, certainly the fact that they may prove of practical value should not be held against them. The same is true of some of our senior courses. It has been suggested that certain courses might be omitted be-

cause the student could study them by himself if he cared to. This could be said of practically any course in school and applies especially to the courses that it is said will improve our present curriculum.

What is the matter then if it is not the curriculum? Let us see what a college consists of: Students, faculty, campus, buildings, curricula, traditions, college life, college organizations, football, basketball, St. Pats, etc. The students constitute the raw material, the graduates the finished product. In going through this mill for four years, what processes take place? The students attend classes a certain portion of their time, they spend a portion of their time studying—the rest is devoted to college activities. Personally, I believe that the influence of their environment outside of the classroom affects the finished product as much, if not more than that of the classroom. If they lose their perspective in regard to the relative importance of things, during their college life, it may take several years to regain. How many students are more interested in athletics or in some other college activity than they are in engineering? If that is true while in college will they not lose sight of the main goal for several years afterwards? If during four years of college they acquire habits of extravagance, of easy living, of wasting time, of questionable amusements, will they not be materially handicapped on leaving school?

I am firmly convinced that the only way a college can improve the character of its graduates is by coöperation of the faculty in endeavoring to inspire broader and higher ideals among the students. It cannot be done in any one course or in any one department. No new course can be introduced to take care of it. If the faculty can inspire the students so that they will be more interested in engineering than they are in other things, then and not until then will we turn out better engineers.

PRESENT TREND OF ENGINEERING EDUCATION.*

BY G. M. BRAUNE,

Dean, School of Engineering, University of North Carolina.

The Present Trend of Engineering Education seems to be towards a cultural, administrative, and business training—including, of course, fundamentals of professional subjects, as opposed to the purely narrow technical training—and also towards a closer correlation between the industries and the schools. The majority of directors of engineering education are on the whole in accord with the present trend of engineering education; but the methods and means to attain the objectives are varied depending on the personality of the directors and also on the traditions and local influences surrounding a particular school of engineering. We may assume, however, that all agree that the trend is, and should be, in the direction of training the young men for a new era in the world's affairs.

Looking backward for only a few years and noting the great change in the activities of the engineer, we awaken to the fact that the members of this profession of to-day and of the future will occupy quite a different position in relation to human affairs. Not more than thirty or forty years ago the majority of engineers were considered merely technical helpers or advisers and were supposed to know nothing about matters relating to public, political and human affairs. The engineers themselves were contented and satisfied with this state of things, and even to-day there are probably quite a few who scorn any activities except the participation in the discussions relating to their own particular line of technical work. Realizing that the present trend in engineering education is to turn out a young man with considerably more

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knowledge than mere technical fundamentals, with ability to think and reason, with a high conception of his duty in relation to human public affairs and one who will be an economic asset to the community, we ask ourselves what should be the ideals in our educational methods to obtain these objectives.

Admitting for the sake of argument that the engineering schools are not keeping pace with the advancement of the engineering profession, where, then, does the shortcoming lie? Is it the fault of the curriculum contents, of the character and experience of the teachers, or of the product that the universities are receiving from the average high school? If one should judge from reading the various papers and discussions on engineering education and from his own personal observations, one is inclined to the belief that the shortcomings exist surely in these three, and probably in other factors. When a large corporation or a great public commission is on the eve of engaging an administrator or an executive to direct the affairs of its institution, it seems the wise thing would be the preparation of a set of specifications covering the qualifications that the applicant should have. Assuredly such a method could well be applied in engineering schools when deciding on the kind and method of training young men should get in preparation for the engineering profession. A paper appeared a few years ago in the Society for the Promotion of Engineering Education (*Proceedings,* S. P. E. E., 1922) setting forth in a most admirable way a set of specifications that to my mind presents a good start in the solution of this much discussed problem of education. I refer to a paper entitled "Preparing the Engineer for the New Era," by the late John H. Dunlap, former Secretary of the American Society of Civil Engineers. These ten specifications are as follows:

1. Every engineer shall know his environment.
2. Every engineer shall know himself.
3. Every engineer shall think well.
4. Every engineer shall write well.
5. Every engineer shall speak well.

6. Every engineer shall know the sources of scientific information.

7. Every engineer shall be skilled in the use of the method of applied science in the solution of engineering problems.

8. Every engineer shall be thoroughly trained in costs and values.

9. Every engineer shall prove himself to be an economic asset in his work, and shall understand the commercial and ethical aspects of professional practice.

10. Every engineer shall be taught throughout his college course that one of his chief functions in life is to serve his community.

I believe that the consensus of opinion among engineers and engineering educators is that the present desired aim in engineering education is to train young men to conform to these ten specifications. Now, we realize that with the product that the universities are getting from the majority of the high schools, it is quite impossible to fully and adequately conform to these specifications in a course covering a period of four years. This criticism, if it is regarded as a criticism, applies to high schools scattered over the entire country.

Faced with this handicap, the directors of engineering education have been discussing the advisability of lengthening the course to five or six years. Many divergent views have been expressed on this question, and probably little unanimity exists when the contents of the lengthened course are considered. However, all agree that much time and effort are lost during the freshman year in the attempt to mold the young high school graduates to conform to the first five specifications. A gap exists between the present high school training and the University which, if supplied properly, would begin the formation of a product that would save considerable mortality and provide engineering schools with far better material upon which to build. After much thought, and after conferences with others who are experiencing this difficulty, I would suggest, as a bridge for this gap, an adjustment year at the University—call it a preëngineering year if you wish—

which would give the high school graduates sufficient time to find themselves in an environment totally different from that to which they have been accustomed. Believing that this first year would accomplish several distinct purposes, I would suggest that the contents of the curriculum should be very carefully chosen. I will not attempt in this paper to outline in detail a course of study for this preëngineering year, but in general it should contain a rigid review of high school mathematics, with emphasis placed on methods to develop the students' reasoning and thinking faculties. A carefully designed course in English should be incorporated, in which training should be given in correct writing and the power to express one's thoughts intelligently. I believe that most teachers find high school graduates woefully deficient in the elements of these two subjects. There might also be included courses in History, Chemistry, Botany, practice in the art of lettering, free-hand sketching and the use of drawing instruments. It is assumed that these first year students would be under the guidance and advisorship of the engineering faculty. I would consider this last provision an extremely important one, because there is a more rigid requirement as to human material in the engineering schools than in the academic departments, and because at the end of this first probationary year the engineering faculty should determine who would be fit material for the engineering school. For those whose interests lie elsewhere, no time would be wasted as the preliminary training would permit those not elected to continue their studies in other schools.

I feel strongly that the principles of this probationary year are economically sound; furthermore, it would enable the engineering school to get a far better selection than is secured under the present system of a straight four-year course. Armed with this preliminary training, the successful candidates entering the engineering schools would be able to approach their work with better understanding than the immature high school graduate. Because of the introduction of this preëngineering year, it surely would not be the intention

to increase the technical contents of the four-year engineering course, nor to indulge in any further specialization; but it would be considered as a means to enable the students to get a better foundation for the engineering curriculum which would follow in the regular four-year course.

We should not say that engineering schools are specializing or are too technical because professional courses in specific branches are offered in the senior year. These subjects are offered to the students not primarily to instruct in special professional branches, but to educate the young men; that is, to draw on their ability to think and apply the theoretical principles of the arts and sciences that they have been studying for two or three years. When visiting one institution a few years ago, I was shown, with much pride on the part of the head professor, elaborate shop drawings of structural work that had been prepared by his senior students. Such instruction is an attempt at specialization that should be condemned. The making of shop drawings with elaborate rivet spacing carried to the nearest sixteenth of an inch and other shop kinks can be learned much quicker and to better advantage in a bridge drafting room. Only enough detailing should be done to enable the students to apply the principles of stress analysis, the fundamentals of which they have studied in mechanics and strength of materials. Similar sentiments in regard to other professional courses no doubt occur to the reader's mind. Specialization should be taken up in the graduate year and by those students who wish to spend additional time in the university after the completion of the four-year course plus the preëngineering year. It is encouraging to note that the majority of high grade institutions have about abandoned the plan of cataloging special departments of railroad engineering, sanitary engineering, highway engineering, structural engineering, etc., and have discarded the habit of awarding degrees in these specialized courses at the end of a four-year period.

I would not attempt to include in this paper my personal views as to the proper subjects that should be found in an

engineering course; but it would be perfectly feasible to design a course that would tend to mold the students in conformity with the ten specifications as outlined before. There is hardly any subject found in an engineering curriculum that would not enable the real enthusiastic teacher to give the student some training in the art of thinking well, writing well, and speaking well. For instance, we might select reinforced concrete as a subject to illustrate practice in thinking. It would show poor judgment on the part of the teacher, and it would be an injustice to the student to commence the solution of problems by merely substituting lengthy complicated formulae, even though the derivation given in the text book has been memorized. An excellent application of the reasoning and thinking ability of the student can be demonstrated in solving problems in this and other special subjects by applying the simple fundamentals of mechanics and strength of materials before any formulae derivations have been attempted. It should be shown, of course, that the formulae are merely short cuts to save time and excessive clerical work.

However, we must presuppose a staff of inspiring teachers with ample experience and education; otherwise, an ideally designed course would permit only a partial solution of the problem. A better and careful selection of engineering teachers as a means to raise the qualifications of the product is part of the present trend of engineering education.

As further means of improving the product of the engineering schools, the leaders of industries, and I believe a large percentage of engineering educators, advise a closer relation between the schools and the industries, and a decided trend of engineering education is in this direction. Several methods have been proposed to attain this closer relation and some are being tried out. I mention three plans that have possibilities and probably are functioning in some cases.

First: Upon the completion of the high school the young men could be placed in the industries for one year before entering the university. A decided disadvantage under this plan is the break or gap between the high school and university that it necessitates.

Second: After spending two years or more at the university, the students could be placed in the industries for one year. With the outside contact that they have thus obtained, they should complete the rest of the university work with more initiative and enthusiasm.

Third: The outside contact could be secured by placing students with the industries during their summer vacations. Under all three plans we would assume a certain amount of faculty supervision and coördination, but obviously only to a limited extent.

Another plan, and apparently the most logical one, is some form of coöperation whereby the students would spend part time with the industries and part time at school, and thus secure some practical experience simultaneously with the theoretical training. Under this form of contact the young men would always be under the guidance and supervision of the engineering coördinator and they would continue as active students of the university. It seems without doubt we could secure better results under this method than from the other plans mentioned.

The most outstanding example of this phase of education is found in the University of Cincinnati, where coöperative education was introduced by Dean Herman Schneider in 1909. Although Cincinnati has been highly successful in the cooperative work and the Cincinnati plan has been followed by other schools with much success, still many engineering educators seem to look askance at the coöperative system of education. They maintain that this plan could only succeed at an industrial center where close coöperation could be secured between the university and the industries. This objection is not valid, however, as it has been demonstrated that the cooperative system can be made successful even though the school is situated at some distance from industrial centers.

There is no fixed and fast system in coöperative education. The plan should be designed to suit the conditions surrounding the school. No doubt there are institutions where coöperative education should not be undertaken, but there are many schools that could greatly improve the product they are turning out if some kind of coöperation was introduced. In September, 1922 the University of North Carolina introduced a

coöperative system quite different from the Cincinnati Plan, whereby the students alternate between school and outside industries during the junior year only. The periods of alternation are considerably longer than those at Cincinnati and were arranged to suit the Christmas and Easter vacations. The school has a successful coöperation thus far and the students, as well as the industries, are highly pleased with the plan.

I have always found a very sympathetic attitude on the part of the practicing engineers toward this phase of education and I believe the objection on the part of the university professors comes from a misconception of the system and a natural aversion to something radically different from what they have been doing, since it does entail a considerable rearrangement of courses and an additional burden to the regular teaching schedule.

I have attempted to bring out in this paper the present trend of engineering education and to offer some suggestions whereby we hope that the standard of the product may be raised. I do not think the directors of engineering education should admit that the schools are turning out an excessively poor product for the industries, but undoubtedly there is much room for improvement. In striving to raise the standard, we would, however, expect a sympathetic attitude and advice from the industries and practicing engineers; especially would this be due institutions that are trying to work out the problems through some system of coöperation with those who will be employers of our future engineers.

DISCUSSION.

C. A. Mees, Consulting Engineer, Charlotte, N. C.: As being absolutely untrained in pedagogics, I hesitate to advance opinions, either in refutation or commendation of statements and principles expressed by a man who has made teaching his life work. These remarks are, therefore, presented with due apologies.

The late Mr. Dunlap's specifications as to the qualifications of an engineer are entirely comprehensive, and if it were possible to offer a training course which would accomplish all these things I am sure that we, of the older school would have to step aside.

In the past it has been considered quite sufficient that the 7th clause in the specifications should have been observed in training engineers; namely, that he should be skilled in the use of the method of applied science in the solution of engineering problems. Engineers, as a whole, have become dissatisfied with their status because of the fact that through such training they become merely tools for another who himself reaped the harvest, to a large extent, at the expense of the engineer. This dissatisfaction has compelled attention to the necessity for a much broader training, and it is gratifying to note that in many of the technical institutions conscientious efforts are being made to give breadth, as well as depth, to the mental equipment of the students.

The greatest obstacle to this accomplishment which I can conceive lies in the narrowness of the teacher himself, because in most cases, he as well as ourselves of the older school, has been trained on the narrowest of lines, and it is exceedingly difficult to effect readjustment. Of course as men, such as Dr. Braune, succeed in producing broader-trained men, some of these will naturally take the places of the older teachers, and, with time, the influence of their broader outlook will be reflected in the methods of teaching.

The preparatory course advocated by Dr. Braune surely seems to be desirable, but it cannot be forgotten that the burden of training one's children, already very heavy by comparison to what it used to be, will become greater. Pre-arranged self-help might offset this disadvantage.

I am not at all sure in my own mind that coöperative education, such as is practised at the University of Cincinnati, Antioch College, and now at the University of North Carolina, will effectively help the student because such practical ex-

perience as he gets during the periods of industrial employment is, of course, specialized, and it is difficult for me to conceive that the services of such an apprentice are not actually used, in most cases, to relieve the organization, with which they are connected, of real drudgery. It can hardly be expected of the employer that he should give to the apprentice all-round experience such as is necessary to supplement classroom work. I believe that some men actually do this, however, and the student who receives that advantage is very fortunate.

I am also inclined to believe that short periods of alternation between classroom and shop are demoralizing, perhaps more so on the teaching staff, than on the student, and there is required of the faculty members especially active, interested attention, to insure for the student uninterrupted progress in classroom training.

There is in my mind no doubt but that the student should have some practical experience along professional lines during his educational period to stimulate interest in his studies and to demonstrate the application of principles learned in the classroom, even though this be most elementary, and I believe that this is best accomplished by requiring of the student that he serve a year's apprenticeship in professional practice between sophomore and junior years.

The things which I believe will be most effective in broadening our future engineers may be summarized about as follows:

I place cultural development first. Especial effort should be directed toward compulsory writing and speaking of good English. A man should be taught to think on his feet, because in that way good sales are made, and the real trouble with engineers is that they do not sell themsleves to the best advantage. Speeches, debate and declamations help largely. An appreciation of music should be fostered, perhaps through compulsory performance in Glee Club, band or orchestra.

Next I should stress the point of teaching how the student may find scientific information. Incidentally I might say

that I believe that a much more thorough demonstration of the student's ability to succeed is proven in the conduct of examination wherein the student will be permitted to avail himself of any source of information known to him in the answering of problems.

And lastly, I think that a thorough course in economics and business practice, than which I can imagine few things being more interesting, should be taught by an especially able man, and by lecturers selected for their qualifications along this particular line. Students should appreciate the value of a dollar, and for most students this must be taught, because until they have passed through college they themselves have earned but little. They should also appreciate the necessity for adequate capital earnings, because without these their professional activities will not be sought, in the majority of cases at least.

J. E. Willoughby, Chief Engineer, Atlantic Coast Line Railroad, Wilmington, N. C.: The present purpose of a technical education is to fit the student for future work in some chosen line. That element which will be of greater benefit to a student pursuing the study of civil engineering preparatory to entering into railway, highway or similar construction and maintenance, is that which tends to develop in the student first—confidence in his own judgment, and then ability to decide and to direct. The course of study in a school of civil engineering is limited principally to text books and lectures on the fundamentals. The practical work accomplishments of the student when in college do not involve responsibility for economic expenditure of moneys. The course of study should be such as will develop the capacity to exercise correct judgment after analysis of the conditions obtaining for any particular engineering problem. The education will continue for many years after the bachelor's degree is conferred. It has long been a definite practice of the writer to recognize that the industries must pay the cost of completing the education of technical graduates and to that end to employ by prefer-

ence those persons lately receiving the bachelor's degree for the minor positions of chainmen and rodmen on location, construction and maintenance parties so that the student's education may continue without interruption to the end desired:

> The development of a capacity to solve correctly the problem at hand and to design and direct works which will require the least economical expenditure of funds for accomplishing the purpose.

While I am in accord with the author as to ten specifications (only I would not put the ten in quite the same order as the author), I do not favor a preëngineering year. The preengineering year will defer for one year the beginning of the completion of the education which completion only comes with the actual responsibility for the expenditure of moneys in the creation of engineering works. The writer favors, however, the student being placed in industrial work for one year between high school and college. The student then will learn to observe practical methods of work, and the time required after graduation for that same purpose will be lessened. The writer does not favor breaking the continuity of the collegiate course when once begun, except for such vacation work in the industries as may offer. There is a very definite advantage to keep a machine once started in motion until the work proposed is completed.

K. E. Hendricks, Consulting Engineer, Asheville, N. C.: There is, no doubt, general agreement among engineers that the present trend of engineering education is towards a broader training in cultural and scientific subjects with particular emphasis upon English and public speaking. This broader training should prepare and stimulate engineers to take a more prominent part in the public affairs than they do at present. The engineer plays an important part in the welfare and upbuilding of the community and this is increasing as civilization advances.

Engineering educators have encountered serious obstacles in attempting to broaden the course in engineering, however

much they may realize the desirability of doing so. The engineering course, as usually laid out, is considerably more difficult than the academic course. Additional subjects could be added to the course only by decreasing the time allotted to each and this would result in superficiality. The only practical method, therefore, of broadening the course in engineering is to lengthen it to five or more years. The author has suggested the introduction of a preëngineering year in order to give time for these additional subjects. This preëngineering year would also give an opportunity to eliminate the unfit and unprepared before entering upon the regular course. It is a well known fact that a great many high school graduates are not properly prepared for the course in engineering. This weeding-out process must necessarily occur in the first year after high school, and to call it a preëngineering year merely changes the name without curing the trouble. It would seem that the proper place to cure the defects in high school training is in the high schools themselves.

In the usual four-year course there is an overcrowding of purely technical subjects in the last year or two. By adding an additional year after the senior year these technical subjects could be spread out and more time given to other subjects when the student is more mature and better prepared to profit by them.

THE LANGUAGES IN TECHNICAL EDUCATION.

BY L. E. HINKLE,

Professor of Modern Languages, North Carolina State College.

Inasmuch as technical education is postulated upon the attainment of certain very definite aims, the teaching of the languages in educational institutions of this type assumes a character that makes the problems connected with such instruction very different from those that prevail in institutions whose chief purpose is the cultural development of the individual through what might be called the disinterested pursuit of learning. There the value of the languages lies within themselves and has no necessary reference to their connection with other branches of human endeavor. In technical institutions it is exactly these other phases of human activities that must, of necessity, determine the approach to the teaching of these subjects. In the strictest sense, there is no subject taught in such institutions merely for the sake of the subject itself. Values are measured in terms of the contributions made by the subject to the larger aims to be attained by the educational endeavor itself. How can instruction in the languages be made to fit into such a scheme of education as this and what functions can they perform in accordance with such ideals? It is believed that the answer to this question is contained, in some measure at least, in the following considerations.

The very first and most fundamental aim of all technical education is the accumulation of scientific knowledge for practical purposes. It matters not, in such educational procedure, what be the field in which proficiency in accomplishment is desired, this can not but be based upon a fund of scientific knowledge. Looked at from this standpoint, technical education is nothing more than an attempt to apply scientific knowledge to practical problems. Every expert in the field of tech-

nology must primarily be a scientist and his success in his chosen field is very largely determined by how well he has, during the period of his education, equipped himself in, and for the attainment of, such knowledge.

Since the bulk of such scientific knowledge lies outside the field of any one language, the very first and foremost of the functions of language instruction in technical education is to give the student a mastery of the important languages of the world sufficient to enable him to make first hand use of them in the acquisition of this information. Since one of the principle aims of such instruction is a mastery of scientific literature in any language it implies a greater amount of time to be alloted to such purposes than is ordinarily given. All technical institutions should take account of the time that is given to language work and ask themselves whether or not it is sufficient to attain this object. If not, then it is incumbent upon such institutions as fall short in this respect to make the proper adjustments of their curricula if they hope to attain the most fundamental aim for which they exist, viz., the training of expert technical scientists. It is possible of course to gain a high proficiency in Science without such training, but it is also quite unlikely that such scientist will stand in the lead in his chosen field, if he must confine his powers of accumulation of facts to his own experiments in the laboratory and to his investigations carried on in his native language.

A certain amount of such knowledge can be had through translations. However, there are certain very serious objections to relying solely upon translations. Aside from the inaccuracies necessarily inherent in such works, they are generally matters of history in their respective science before the task is completed. When one considers the numerous investigations and publications that are made daily in the foreign fields along all scientific lines, the problem of such translations becomes herculean, and, up to the present time, only those productions in foreign languages that have, for one reason or another, struck the fancy of random individuals have been translated. There has been no general attempt made at

such work. Technical institutions would do well to supplement the work of their language departments by arranging for a systematic and supervised translation of articles of scientific interest occurring in current foreign language publications. In doing this, however, it should be kept in mind that such work is merely a supplement to the work of language instruction and by no means should it be allowed to take the place of the teaching of the languages themselves. Inasmuch as this has not yet been done by these institutions they have, no doubt, thus far failed in the accomplishment of one of their major aims.

A similar situation prevails in the industrial field. Graduates of technical institutions are much more closely connected with the industrial activities than is the case, generally speaking, of the graduates of the purely literary institutions. In fact, training for industrial leadership is one of the aims that actuated the establishment of such institutions and one which must be attained if they are to justify their *raison d'etre*. But such leadership can hardly be said to be attainable if the sources of such knowledge are confined to any one language. Limited land area and density of population in the leading European states, for instance, have, per se, converted them into industrial communities and forced them long ago into a consideration of the problems connected therewith that are just now beginning to appear on our horizon. A great fund of literature on such subjects has been produced and even less of it has been translated into English than is the case of the sciences. Consequently another of the great functions of language instruction in technical education is to equip the student in such a way as to make this storehouse of knowledge available to him. The technical student must be put in touch with industrial literature and sufficient time must be given language instruction to enable the acquisition of a practical working knowledge of the important languages of the world, if the graduate hopes to be an expert in the sense that he is fully abreast of his times and familiar with the problems of

an intricate industrial world. Certainly unless such an ideal is attained on the part of a large number of the graduates of any technical institution it has thus far fallen short of one of its principle purposes. Industrial leadership that fails to comprehend its problems in the light of world accomplishments is very largely a case of the blind leading the blind. It is unfortunately true that many of our technical institutions, in the past, have not recognized the value of a study of such literature in their language departments and consequently have not seen to it that such courses were offered. There is a great field of service here and it is hoped that no such institution will neglect it in the future.

The importance of the languages in technical education becomes even more apparent when we turn to the other great specific aim of such training. I refer to the commercial world, especially that portion of it which has to do with our foreign trade. Due to conditions arising out of the recent World War, this country has seen its foreign trade demands increase in leaps and bounds. We have, more or less suddenly, waked up to the recognition that we are a creditor nation and with this realization has come an increased appreciation of the function of the languages in this field. Unhappily, language instruction as formerly conducted in our educational institutions left us woefully lacking in this respect. So much so in fact that numerous of our commercial and banking establishments doing business abroad have found it necessary to establish courses of language instruction for their employees who are engaged in this work. It soon became apparent that, if we were to trade with a people using a language different from our own, the first and prime requisite for success in such enterprise was a mastery of their language. Without this knowledge we would soon be placed in a position of seeing our would be customers seeking a seller among those peoples who were more fortunate in this respect than we. But, obviously, business establishments cannot be expected to perform this duty for society. This is properly

the sphere of our educational institutions, and especially so of those engaged in training for technical purposes. Consequently it becomes incumbent upon such institutions to take up the problem of language instruction along commercial lines and provide for this in such a fashion as to turn out men who are really and accurately efficient in one or more of the important languages of the world. In so far as this is done they will meet with the approbation of the business world, while a failure to perform this apparent obligation can scarcely fail to meet with censure from this source.

The following quotation from a statement made by the foreign sales manager of one of the largest manufacturing establishments in America typefies the attitude of the business world towards this subject. He writes as follows:

"It is very important that our American Institutions of learning, particularly those of a commercial character, should stress the importance of a thorough business knowledge of one or more of the important foreign languages. It is extremely desirable that American business representatives going to foreign countries should have a thorough knowledge of the languages spoken in those countries. It is very unfortunate that the languages are not given a more prominent position in the program of our institutions of learning. It would give business concerns a better opportunity to get desirable foreign representatives from the men trained in their American organizations if a larger proportion of the students graduated in America had received a knowledge of the modern, commercial languages."

Foreign trade requires not only efficient instruction in the commercial aspects of the languages themselves, but we have, from the same source, a demand on technical institutions to the effect that all language teaching lead to a broader knowledge of foreign peoples. If we would have relations with other peoples, commercial or otherwise, it behooves us to know something about them. Here again our language courses as given in the past have left us sadly deficient. In spite of the fact of all such instruction heretofore given, and, in spite of the tide of immigration constantly pouring into

this country, as well as all other sources for such information, most of us have gone on in blissful ignorance of the manners, the customs, habits, and mental attitudes peculiar to foreign peoples. So far as the average was concerned the whole world lived and moved and had its being in the same manner as ourselves. Our whole foreign policy in the past has been nothing more than an expression of our provincialism growing out of our indifference to things beyond our borders. The affairs of other people must be none of our concern.

But as a result of recent developments, technological and political, we suddenly and unexpectedly find ourselves thrust out of our secluded position and made citizens of the world whether we will or not. Then it becomes suddenly clear to us that the performance of the duties devolving upon us as world citizens demands that we give heed to the character of the other peoples on earth. And the logical place to turn for such information in the educational world is the field of language instruction. Historical and sociological studies give us general viewpoints in such matters but it is reserved for the study of languages to give us a real insight into the soul of a people and stir in us an understanding sympathy with their otherwise peculiar modes of life and thought. All language instruction should lead to this purpose, but more especially there should be given courses in such departments of instruction that have to do primarily with a study of the manners, customs, and characteristics of the peoples whose languages are studied for the special purpose of broadening our knowledge along such lines and thus creating a better understanding of our foreign relations. This becomes especially true of technical institutions, when we consider the fact that the graduates of such institutions will, in the main, be thrown either in the industrial or the commercial world and thus have a more intimate touch with foreign affairs than the average of our citizens.

There is still one other important function that language instruction can perform in technical education. Such work

can and should become a great medium in the preparation for domestic citizenship. No type of education should lose sight of the fact that its products must, first of all, be citizens of the community where they cast their lot. Perhaps the training for good citizenship is the greatest duty to society that education can perform and those subjects that contribute to this aim should be ranked high in educational values.

In this respect the study of the languages holds a very unique position. There can be no mastery of any language in any of the above-mentioned phases, scientific, industrial or commercial, without first a foundation based upon the purely literary accomplishments in the language under consideration. Now, it is through the study of literature that our moral ideas are very largely influenced and our ideas of values fixed. And the answer to the question "What things are worth while?" in the minds of a majority of the citizens of a community will determine the direction that its culture will take and the height to which it will attain in its civilization. Of the subjects that can operate in the shaping of a correct answer to this question, I can conceive of none that can be more effective than the great literatures of the world. It would seem strange indeed that the youth of our land could be imbued with the ideal values set forth by the great literary geniuses of the world in their masterpieces without modifying their own viewpoints accordingly. Failure to keep this function of language work in view is to lose sight of one of the primary aims of all education.

Another great contribution to the equipment for domestic citizenship coming from this same source is training in the ability to form correct analyses of human character and motives. While it is true, of course, that the best study of man is man himself, it is also true that it is obviously impossible for the majority of persons, in one short life, to come in contact with a sufficient number of individuals to enable him to acquire much proficiency in this process. The great literatures of the world have, however, stored up for us all possible

types of individuals and all possible varieties of human experiences. There, the whole spiritual life of the race passes before us in kaleidoscopic array as it were. Literature is the great text-book of human nature and nothing could make a greater contribution to the equipment for citizenship than a mastery of this text.

And finally, it should be noted that it is largely through the study of literature that there is developed one other very important requirement for good citizenship, viz., the gift of the open mind. This trait, in its simplest analysis, means nothing more than the ability to detach oneself from his own personal and local prejudices and look at a proposition from an impersonal and general viewpoint. Now the great mass of literary problems have to do with exactly this kind of training. Of necessity, it becomes the first care of every teacher of languages and literature to develop this attitude in his students when they are confronted with one of the works of the great masters. To quote from a recent writer on this same subject: "The student who has studied a novel of Balzac, or Zola, or a play by Dumas fils, or Augier, and who has not found occasion to make an analysis of the motives and sentimental impulses involved, or in other words, to exercise his judgment while inhibiting his own individual prejudices would be rare indeed." Such, at least, are *some* of the many services that language instruction can render in the field of technical education.

SANITARY ENGINEERING COURSES OF ENGINEERING COLLEGES IN THE UNITED STATES.*

BY ISADOR W. MENDELSOHN,

Associate Sanitary Engineer, United States Public Health Service.

For several years past, inquiries have been received by the Surgeon General of the United States Public Health Service for information as to the colleges in the United States giving sanitary engineering courses, the subjects included in such courses, the number of graduates, etc. In order that reliable data regarding these topics might be made available, a letter was sent, in January, 1923, to 129 engineering colleges in the United States † containing the following queries:

1. Does your department include a complete course in sanitary engineering?
2. If so, when was it established?
3. What are the degrees granted?
4. What subjects are included in the course of sanitary engineering leading to such degrees?
5. What is the number of graduates, by years?

It was necessary to send a follow-up letter in February, 1923. As a result, replies were received from 126 colleges. In February, 1924, another letter was sent, but only to those engineering colleges in which, according to the replies received in 1923, regular or optional courses in sanitary engineering were offered. In this letter, additional information was sought with which a reliable comparison could be made between the sanitary engineering and civil engineering courses. The compiled data were sent to each college in Table I for review, and the replies were incorporated in the tables as finally presented.

* Reprint from the Public Health Reports, Vol. 39, No. 33, Aug. 15, 1924, pp. 1989–1997. (By request.)

† The 129 engineering colleges listed in Higher Education Circular No. 20, issued by the Bureau of Education, Department of the Interior.

TABLE I (*a*).

NUMBER OF GRADUATES ANNUALLY IN EXISTING SANITARY ENGINEERING COURSES OF ENGINEERING COLLEGES IN THE UNITED STATES.

College.	Year.																																		
	189—									19—																										
	2	3	4	5	6	7	8	9	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
2. Columbia University *	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0	0	0	0	0	0	0
3. Harvard University	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	5	2	3	5	2	3	4	4	3
5. Massachusetts Institute of Technology	6	0	3	4	4	4	3	1	4	4	7	4	2	5	6	3	2	9	12	15	14	15	19	12	18	17	5	6	2	3	7	2	5
6. Pennsylvania State College	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	5	11	5	7	6	6	8	4	2	1	3	1	6		
7. State University of Iowa	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	5	8
8. University of California	..	..	..	..	..	..	..	..	..	..	..	..	..	6	19	16	2	5	3	0	2	2	3	2	1	5	1	1	1	2	1	2	5
9. University of Illinois	..	..	1	2	0	1	1	1	2	1	1	1	3	2	5	1	2	6	4	6	5	5	7	9	5	8	1	4	2	2	2	2	5
11. University of Michigan	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4	15	32	40	26	0	7	9	12	6	11	
14. University of Texas †	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
15. Villanova College ‡	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1

* 3 to 10 graduates per year from 1911 to 1917, inclusive. In 1917 course changed to six years in length.
† Established in 1903. In the last 15 years there have not been more than four graduates in Sanitary Engineering.
‡ No graduates.

TABLE I (*b*).

NUMBER OF GRADUATES ANNUALLY IN DISCONTINUED SANITARY ENGINEERING COURSES OF ENGINEERING COLLEGES IN THE UNITED STATES.

College.	Year.												
	19—												
	11	12	13	14	15	16	17	18	19	20	21	22	23
1. Carnegie Institute of Technology	2	0	2	0	1	0	0	1	1	0	1	..	..
13. University of Pittsburgh	..	..	..	..	..	..	..	..	..	..	..	..	1

TABLE I (*c*).

NUMBER OF GRADUATES ANNUALLY IN SANITARY ENGINEERING OPTIONAL COURSES OF ENGINEERING COLLEGES IN THE UNITED STATES.

College.	Year.													
	19—													
	11	12	13	14	15	16	17	18	19	20	21	22	23	24
4. Iowa State College *	..	..	..	..	..	4	5	3	0	4	5	6	8	7
10. University of Kansas	..	1	7	6	0	3	2	0	3	0	3	3	0	3
12. University of North Carolina	..	..	..	..	..	..	..	..	..	..	..	..	..	..
16. West Virginia University	..	..	..	0	1	0	0	0	0	0	0	0	1	0

* Before 1916 there were about six graduates.

The compilation of the data disclosed that many colleges had adhered closely to the questions of the first letter and those not giving sanitary engineering courses had replied in the negative without qualifying their replies as to whether they included any sanitary engineering subject in their other engineering courses. Those colleges which offered sanitary engineering courses differed considerably in their unit of work, the "hour," "point," "credit," or "course" being used for a basis. Where electives were permitted in the courses, it was the plan to credit them to the proper subject

groups according to the best available information. Unless definite information was furnished, a blank space was left in the table.

It is of particular interest at this time, when various definitions of the sanitary engineer are being proposed, to note the following section from the 1922 catalogue of Columbia University, in which the scope and the field of usefulness of the sanitary engineer are extended considerably beyond that now usually recognized, and, at the same time, his work is defined in a clearer manner:

The sanitary engineer must not only be able to design and construct water-purification plants and sewage-disposal systems, but he must understand the chemical and biological processes upon which the successful operation of these plants is based. He must not only be able to construct such engineering features as will prevent epidemics and further the health and comfort of individuals and communities, but he must have a knowledge of bacteriology, sanitary statistics, and the sources and modes of infection.

While mathematics, mechanics, and physics are the theoretical basis for the work of the civil engineer in design, construction, and management, the sanitary engineer adds to these the collateral sciences of chemistry and biology.

Through the courtesy of Prof. Charles Gilman Hyde, of the University of California, the following interesting information appearing on a circular issued for the benefit of visitors to the university on "Engineers' Day" is presented:

UNIVERSITY OF CALIFORNIA, COLLEGE OF CIVIL ENGINEERING, COURSE IN SANITARY ENGINEERING. ENGINEERS' DAY, MARCH 14, 1924.

The sanitary engineer.

Fundamental university training in—
- Bacteriology.
- Biology.
- Chemistry.
- Geology.
- Hydraulics.
- Hygiene.
- Mathematics.
- Mechanics.
- Physics.
- Structural theory.

SANITARY ENGINEERING COURSES.

Specialized university training in—
- Waterworks and water treatment and purification.
- Roads and pavement.
- Sewerage and sewage and industrial wastes treatment and disposal.
- Structural design.
- Public health and the control of the environment.
- Wastes collection and disposal.

Sanitary engineers become—
- City managers.
- City engineers.
- Highway engineers.
- Health officers and public health administrators.
- Superintendents of water and sewage treatment works.
- Operators of industrial wastes plants.
- Engineers in the United States Public Health Service.
- Engineers in State, district, and city sanitary engineering departments.
- Designing, supervising, and consulting engineers on all manner of hydraulic, municipal, and sanitary problems.

THERE ARE IN THE UNITED STATES 1,500 CITIES OF OVER 5,000 INHABITANTS AND 2,800 PLACES OF OVER 2,500 INHABITANTS WHOSE CITY MANAGERS AND ENGINEERS SHOULD BE TRAINED SANITARY ENGINEERS.

Our Motto: To preserve and promote the public health, human happiness and comfort: To render the highest service within our power to the cause of humanity.

With reference to the foregoing tables it can be seen that up to and including 1917, the year of the World War, the number of sanitary engineering graduates in American colleges increased steadily. The effect of the war upon the number of these graduates is shown with telling effect in the sudden and sharp reduction in 1918. Since then this number has increased gradually. The number of sanitary engineers to graduate in 1924 will be 37, as compared with 69, the number that graduated in 1917.

Considering only the colleges of Table No. I (*a*) and omitting Columbia and Harvard, in which the courses are longer than in the other colleges, the averages of percentages of time

TABLE II.

RELATIVE TIME ALLOTTED TO SUBJECT GROUPS IN SANITARY ENGINEERING AND CIVIL ENGINEERING COURSES OF ENGINEERING COLLEGES IN THE UNITED STATES.

College.	Sanitary Engineering Course—Per Cent. of Total Time in Course Given to Subject Group.						Civil Engineering Course—Per Cent. of Total Time in Course Given to Subject Group.					
	Cultural.	Pure Science.	Allied Engineering.	Sanitary Engineering.	Public Health.	Miscellaneous.	Cultural.	Pure Science.	Allied Engineering.	Sanitary Engineering.	Public Health.	Miscellaneous.
1. Carnegie Institute of Technology	14.9	29.0	40.7	12.7	0.0	2.7	18.9	24.3	49.5	4.1	0.5	2.7
2. Columbia University *	1.3	14.4	61.2	20.5	2.6	0.0	1.2	10.3	82.9	5.6	0.0	0.0
3. Harvard University †	13.0	20.0	45.0	22.0	0.0	0.0	16.0	24.0	55.0	5.0	0.0	0.0
4. Iowa State College ‡	8.9	29.3	50.2	8.9	0.0	2.7	8.9	29.3	54.2	4.9	0.0	2.7
5. Massachusetts Institute of Technology	12.6	36.0	37.2	9.7	1.0	3.5	12.6	30.6	48.6	4.4	0.3	3.5
6. Pennsylvania State College	21.3	26.3	41.4	5.7	0.6	4.7	20.6	21.1	51.4	1.7	0.5	4.6
7. State University of Iowa	11.4	32.6	48.4	7.6	0.0	0.0	11.4	32.6	53.0	3.0	0.0	0.0
8. University of California	5.3	36.7	40.0	10.7	1.3	6.0	4.0	26.7	60.7	2.7	0.6	5.3
9. University of Illinois	13.0	29.6	40.8	12.3	0.0	4.3	11.8	26.4	52.8	4.8	0.0	4.2
10. University of Kansas ‡	7.7	28.0	47.5	16.8	0.0	0.0	12.1	29.1	55.3	3.5	0.0	0.0
11. University of Michigan	17.9	24.8	44.2	13.1	0.0	0.0	.....	.....	.....	.....	.....	.....
12. University of North Carolina ‡	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
13. University of Pittsburg	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
14. University of Texas	15.2	36.4	39.4	9.0	0.0	0.0	15.2	31.8	48.5	4.5	0.0	0.0
15. Villanova College	16.9	35.6	37.3	10.2	0.0	0.0	17.4	28.2	51.4	3.0	0.0	0.0
16. West Virginia University ‡	10.0	36.9	40.3	10.1	0.0	2.7	11.4	28.9	53.7	3.3	0.0	2.7

* Three years of college work required for entrance to three years of professional course.
† Five years of college work.
‡ Sanitary engineering optional course given in civil engineering department.

allotted to subject groups given in Table II for each college course are as follows:

Course.	Subject Groups.					
	Cultural.	Pure Science.	Allied Engineering.	Sanitary Engineering.	Public Health.	Miscellaneous.
Sanitary engineering..	14.2	32.2	41.4	9.8	0.4	2.3
Civil engineering.....	13.3	28.2	52.4	3.4	0.2	2.5

Similarly, for the colleges of Table I (*c*) the averages of the percentages given in Table II are as follows:

Course.	Subject Groups.					
	Cultural.	Pure Science.	Allied Engineering.	Sanitary Engineering.	Public Health.	Miscellaneous.
Sanitary engineering..	8.9	31.4	46.0	11.9	0.0	1.8
Civil engineering.....	10.8	29.1	54.4	3.9	0.0	1.8

From these averages one finds, in a comparison on sanitary engineering and civil engineering courses, that about 10 per cent. of the time allotted to allied engineering subjects in the civil engineering curriculum is replaced largely by sanitary engineering subjects and partly by pure science subjects (chemistry and biology) in the sanitary engineering course. In general, in both courses about one-half the curriculum time is spent on allied engineering subjects, about one third on pure science subjects, and the other one sixth of the time on cultural and sanitary engineers subjects, the last covering the least amount of time.

From Table III it is seen that the sanitary engineering course in the majority of the colleges includes the following subjects: (1) *Cultural*—economics, English, languages; (2)

‡ Sanitary engineering optional course given in civil engineering department.

TABLE III.

SUBJECTS GIVEN IN SANITARY ENGINEERING AND CIVIL ENGINEERING COURSES OF ENGINEERING COLLEGES IN THE UNITED STATES.

Subjects.	Universities Giving Subjects.	
	Sanitary Engineering.	Civil Engineering.
I. Cultural:		
Economics	1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 14, 16.	1, 3, 4, 5, 6, 7, 8, 9, 10, 14, 16.
English	1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 14, 15, 16.	1, 3, 4, 5, 6, 7, 8, 9, 10, 14, 15, 16.
History	5, 6.	5, 6.
Languages	1, 5, 6, 9, 10, 11, 14, 15,	1, 6, 9, 10, 15.
Law (business)	2, 3, 7, 8, 15, 16.	1, 2, 3, 5, 6, 7, 15, 16.
Public speaking	4, 14.	4, 14.
Religious instruction	15.	15.
II. Pure science:		
Biology	1, 3, 4, 5, 8, 9, 15, 16.	1, 2, 3, 4, 5, 8, 10.
Chemistry	All.	All.
Geology	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 14, 16.	All.
Mathematics	All except 2.	All except 2.
Physics	All.	All.
III. Allied engineering:		
Contracts and specifications	1, 3, 4, 6, 9, 11, 16.	3, 4, 6, 9, 10, 16.
Drawing	All except 2.	All except 2.
Electrical engineering	1, 2, 3, 7, 9, 10, 11, 14, 16.	All except 4.
Engineering discussion	1, 4, 10, 16.	1, 4, 10, 16.
Heat engineering	2, 3, 5, 6, 7, 8, 9, 10, 11, 15, 16.	1, 2, 3, 5, 6, 7, 8, 9, 10, 15, 16.
Hydraulics	All.	All.
Industrial engineering	3, 10.	1, 3.
Materials	All.	All.
Mechanics	All.	All.
Public utilities engineering	4.	4, 9.
Railroad engineering	All.	All.
Roads and pavements	All.	All.
Shop	1, 6, 7, 10, 11, 15, 16.	1, 6, 7, 15, 16.
Structures	All.	All.
Surveying	All.	All.
Water power	2, 3, 4, 9, 16.	2, 3, 4.
IV. Sanitary engineering:		
Municipal sanitation	All.	3, 4, 5, 6, 7, 14, 16.
Sanitary laboratory	All.	None.
Sewerage and sewage disposal	All.	All.
Water works and water treatment	All.	All.

TABLE III.—*Continued.*

Subjects.	Universities Giving Subjects.	
	Sanitary Engineering.	Civil Engineering.
V. Public health:		
Sanitary science and public health	2, 4, 5, 6, 8.	1, 5, 6, 8.
Vital statistics	2, 4, 5.	None.
VI. Miscellaneous:		
Gymnasium	All.	All.
Military drill	4, 5, 6, 7, 8, 9, 16.	4, 5, 6, 7, 8, 9, 16.

pure science—chemistry, geology, mathematics, physics; (3) *allied engineering*—drawing, electrical engineering, heat engineering, hydraulics, materials, mechanics, railroad engineering, roads and pavements, structures, surveying; (4) *sanitary engineering*—municipal sanitation, sanitary laboratory, sewerage and sewage disposal, water works and water treatment; (5) *public health*—; (6) *miscellaneous*—gymnasium. In the majority of the colleges the civil engineering course differs in subjects given from the sanitary engineering course as follows: (1) cultural—business law instead of language; (4) sanitary engineering—municipal sanitation and sanitary laboratory omitted. It is of interest to note that (1) biology in its broadest aspects is given by eight colleges in the sanitary engineering course and seven colleges in the civil engineering course; (2) municipal sanitation is offered in the civil engineering course in seven colleges; and (3) sanitary science and public health is included in the sanitary engineering course in five colleges, and in the civil engineering course in four colleges.

In many of the colleges it is noted that certain cultural and pure science subjects are given which are required for entrance into other colleges. It would seem that, through universal establishment of stricter entrance requirements and the giving of these subjects in the high and college preparatory schools, more time would be allotted for advanced pro-

fessional subjects in the college curriculum. This may do away with the necessity for increasing the present length of the college course, a tendency which is becoming more and more evident. It would logically seem that what is needed first of all, before the sanitary engineering course is lengthened, is an overhauling and rearranging of the precollege and college courses to make them conform in a more practical way with the actual work that sanitary engineers perform after leaving college.

TABLE IV.

MISCELLANEOUS DATA OF SANITARY ENGINEERING COURSES OF ENGINEERING COLLEGES IN THE UNITED STATES.

Degree.	Number of Years in College.	College Granting Degree.	Name of Course by Colleges.	
			Sanitary Engineering.	Sanitary and Municipal Engineering.
B.S. (civil engineering)....	4	4, 10, 11, 12, 14, 16	4, 11, 12, 14, 16	10
M.S. (sanitary engineering)	5	*3, 4, 5	4, 5	*3
B.S. (sanitary engineering)	4	1, *3, 5, 6, 8, 9, 15	1, 2, 6, 15	8, 9
Civil Engineer.....	6	2	.....	.....
Bachelor of Engineering...	4	7	7	.....

* From 1916–1919 Harvard University and Massachusetts Institute of Technology were related in regard to the granting of sanitary engineering degrees. From 1923 on, the S.B. in sanitary engineering was not granted by Harvard University.

Table IV shows that the large majority of the sanitary engineering courses are four years in length to a B.S. (civil engineering) or a B.S. (sanitary engineering). The other degrees are Bachelor of Engineering, Civil Engineer, and M.S. (sanitary engineering). The name of the course is generally sanitary engineering, but in four colleges it is sanitary and municipal engineering.

Conclusions.

1. There are ten colleges in the United States now offering full courses in sanitary engineering; namely, Columbia University, Harvard University, Massachusetts Institute of Technology, Pennsylvania State College, State University of Iowa, University of California, University of Illinois, University of Michigan, University of Texas, and Villanova College.

2. Four other colleges are now offering optional courses in sanitary engineering, namely, Iowa State College, University of Kansas, University of North Carolina, and West Virginia University.

3. Of the other engineering colleges in the country, at least 55 are including in their courses the following subjects: Water supply and waterworks, and sewerage and sewage disposal.

4. The number of graduates from sanitary engineering courses in engineering colleges of the United States increased steadily until 1918, when the World War caused a sudden and sharp drop; since then the number has increased gradually. In 1924 the number will be at least 37, as compared with 69 in 1917.

5. According to the average of the regular sanitary engineering courses now offered, the time is allotted to subject groups as follows: (1) cultural, 14.2 per cent.; (2) pure science, 32.2 per cent.; (3) allied engineering, 41.1 per cent.; (4) sanitary engineering, 9.8 per cent.; (5) public health, 0.4 per cent.; (6) miscellaneous, 2.3 per cent.

6. The sanitary engineering course differs from the civil engineering course as now given in the engineering colleges of the country mainly in that about 6 per cent. more time is allotted to sanitary engineering subjects and 4 per cent. more time to chemistry and biology, instead of allied engineering subjects.

7. The regular sanitary engineering course includes the following subjects: (1) cultural—economics, English, languages; (2) pure science—chemistry, geology, mathematics, physics; (3) allied engineering—drawing, electrical engineer-

ing, heat engineering, hydraulics, materials, mechanics, railroad engineering, roads and pavements, structures, surveying; (4) sanitary engineering—municipal sanitation, sanitary laboratory, sewerage and sewage disposal, waterworks and water supply; (5) miscellaneous—gymnasium.

8. The degrees conferred upon graduates from sanitary engineering courses are: B.S. (civil engineering), B.S. (sanitary engineering), M.S. (sanitary engineering), Bachelor of Engineering, and Civil Engineer.

9. The courses are generally four years in length, although one course is five years and another is six years.

10. The course is generally known as sanitary engineering, although in four colleges it is called sanitary and municipal engineering.

It may be that this paper, by disseminating the foregoing data on sanitary engineering courses of engineering colleges in the United States as at present constituted, will bring about a coöperative effort of sanitarians and university faculties with the idea of improving, extending, and making more uniform the course in sanitary engineering offered at the colleges.

Acknowledgments.—It is with pleasure that this opportunity is taken of acknowledging the appreciation of the writer for the assistance rendered (1) by all the university officials, in furnishing the data; (2) by Messrs. H. B. Hommon, L. D. Mars, Sol Pincus, William Firth Wells, and Abel Wolman, in the preparation of the paper; and (3) by Misses Helen Vaughan and Pearl Wolf in the collection and compilation of the data.

NEW MEMBERS.

District No. 1.

JENKS, LEON E., Professor of Chemistry, Worcester Polytechnic Institute, Worcester, Mass.

PHELPS, GUY MERRITT, Assistant Professor of Descriptive Geometry and Drawing, Rensselaer Polytechnic Institute, Troy, N. Y.

SHOUDY, WILLIAM A., Associate in Mechanical Engineering, Columbia University, New York City.

District No. 2.

DRUM, MARTIN L., Professor of Surveying, Bucknell University, Lewisburg, Pa.

EIDMANN, FRANK L., Associate Professor of Design and Industrial Practice, Princeton University, Princeton, N. J.

EVERETT, HARRY S., Professor of Applied Mathematics and Astronomy, Bucknell University, Lewisburg, Pa.

RHODES, WALTER KREMER, Professor of Electrical Engineering, Bucknell University, Lewisburg, Pa.

WILSON, BENJAMIN J., Instructor in Mechanical Engineering, Bucknell University, Lewisburg, Pa.

BUCKNELL UNIVERSITY, Lewisburg, Pa., Emory W. Hunt, President.

District No. 3.

UNIVERSITY OF KENTUCKY, Lexington, Ky., Frank L. McVey, President.

District No. 4.

AITKENHEAD, WILLIAM, Professor of Farm Mechanics, Purdue University, LaFayette, Ind.

BOSS, WILLIAM, Professor and Chief of the Division of Agricultural Engineering, University of Minnesota, Minneapolis, Minn.

BREWER, RALPH E., Instructor in Technological Chemistry, University of Minnesota, Minneapolis, Minn.

EDWARDS, OLIVER C., Assistant Professor of Mechanical Engineering, University of Minnesota, Minneapolis, Minn.

HERSHEY, PHARES R., Instructor in Spanish, Purdue University, LaFayette, Ind.

HILL, HIBBERT M., Instructor in Civil Engineering, University of Minnesota, Minneapolis, Minn.

HYLAN, PATRICK HENRY, Associate Professor of Machine Design, Universiy of Wisconsin, Madison, Wis.

JANSKY, C. M. JR., Assistant Professor of Radio Engineering, University of Minnesota, Minneapolis, Minn.

SCHUCK, ROBERT F., Assistant Professor of Drawing and Descriptive Geometry, University of Minnesota, Minneapolis, Minn.

SOLBERG, HARRY L., Instructor in Mechanical Engineering, Purdue University, LaFayette, Ind.

WISE, JOSEPH ALEXANDER, Instructor in Civil Engineering, University of Minnesota, Minneapolis, Minn.

District No. 5.

EHLE, MARK, Professor of Mining Engineering, University of Arizona, Tucson, Ariz.

GARRAN, FRANK W., Assistant Professor of Civil Engineering, University of Arizona, Tucson, Ariz.

KELTON, FRANK C., Professor of Civil Engineering, University of Arizona, Tucson, Ariz.

SMITH, JOHN W., Instructor in English, University of Arizona, Tucson, Ariz.

SWEET, SANFORD, Head of Chemistry Department, Phoenix Junior College, Phoenix, Ariz.

THORNBURG, MARTIN L., Associate Professor of Mechanical Engineering, University of Arizona, Tucson, Ariz.

SECTIONS AND BRANCHES.

North Carolina Section.—The third meeting of the college year was held in the evening of March 13 at Trinity College of Duke University, Durham. Before the meeting the Section had a supper in conjunction with the North Carolina Physics Teachers Association which had held its annual meeting at Duke University in the afternoon. At the S. P. E. E. meeting there was an attendance of twenty-three including a number of the Physics Teachers Association.

The subject for the evening was "Physics for Engineers," continuing the line of thought started at the preceding meeting at which "Mathematics for Engineers" was discussed. The Program Committee had a speaker from each of the institutions constituting the Section: Prof. C. M. Heck of the N. C. State College of Agriculture and Engineering, Prof. C. C. Hatley of Duke University, and Prof. E. K. Plyler of the University of North Carolina.

Following the three scheduled talks there was a discussion of the subject during which the relative merits of the Metric and English Systems of units were vigorously debated.

D. C. JACKSON, JR.,
Secretary.

NECROLOGY.

JOHN FILLMORE HAYFORD.

John Fillmore Hayford, son of Hiram and Mildred Hayford, was born at Rouse's Point, near the north end of Lake Champlain, N. Y., on May 19, 1868.

He spent four years at Cornell, graduating in 1889 with the degree of Civil Engineer. One of his predominant traits was always to get the fullest from every phase of life or activity into which he entered, whether mental, spiritual or bodily. At Cornell he became especially interested in those courses dealing with mathematics and physics, as a result of which, upon graduation, he entered the U. S. Coast and Geodetic Survey at Washington D. C. as a computer.

In the survey his mathematical skill and remarkable ability soon won for him such recognition that he was made Assistant Astronomer in charge of field parties on the International Boundary Commission in laying out the boundary between the United States and Mexico. For two years, 1892 and 1893, he was in the field on this work and ran the entire line from El Paso, Texas, to Tia Juana, Mexico, on the Pacific Coast.

To those of us who are acquainted with this piece of work, there appears in its story all the romance and adventure which formed such a part of the settlement of our western territory. The party was always guarded by a detachment of U. S. soldiers to keep off the roving bands of murderous Apaches; water in many cases had to be hauled from fifty to one hundred miles; roads and trails had to be made over mountains and through deserts, but even through the heat and waste of this southwestern desert land the party kept moving westward to the Pacific.

It was on this work that he collected much of the data which was later used in his book, "Geodetic Astronomy," which for

wealth of material and clearness of detail remains one of the finest treatises ever written on the subject.

After completing this boundary survey he returned to the United States Coast and Geodetic Survey as Aid, and later as Assistant for the years 1894–95, and was engaged on the various classes of geodetic work done by the survey.

In 1895 he resigned from the survey and returned to his alma mater, Cornell University, as Instructor in Civil Engineering, which position he held until 1898 when he again entered the Coast Survey as Expert Computer and Geodetist.

When Mr. Schott was released from the work of the Computing Division to enable him to devote his time to the completion of the report of the great transcontinental arc of triangulation along the 39th parallel of latitude, Mr. Hayford, then only thirty years of age, took over the duties as Chief of the Computing Division, and in addition became Inspector of Geodetic Work, the latter being a newly created division of the survey's work. In this dual capacity he served the nation until 1909, when he resigned to become Director of the College of Engineering at Northwestern University.

While carrying on the regular work of the two departments over which he had supervision, Mr. Hayford was continually studying the various phases of work and problems which presented themselves, with a view ever to increase the efficiency of its personnel, in introducing new methods, or in revising old methods which would increase the speed and accuracy of the field and office work and effect economics in expenditures. It was during this period that the work of the Geodetic Division attained such a high standing as to bring forth expressions of highest praise from the world's ranking geodesists, Perrier, the French geodesist, wrote:

"There is no example in the history of geodesy of a comparable collection of measurements, made with so much determination, such rapidity, and such powerful means of action, and guided by such an exact comprehension of the end to be attained."

In addition to this he found time to carry on many original investigations. His theory of isostasy brought him international reputation, for which he was awarded the Victoria Medal of the Royal Geographic Society of Great Britain, an honor accorded to but two other Americans. His work with the transit micrometer and precision level has revolutionized longitude determinations and precise level work. And he was a great factor in the adoption of the U. S. Standard Geodetic Datum, which has now become the North American Datum, and by which the geodetic positions on this continent will eventually be accurately coördinated, all being based upon the same datum.

During the time that he was developing his theory of isostasy, he made computations as the figure of the earth, and his values of the lengths of the earth's semi-major and semi-minor, axes, together with the ratio of the polar flattening were in January, 1925, adopted by the International Geodetic and Physical Union at a meeting in Madrid, as being the values which best fitted the various continents of the earth.

He was twice selected to represent this government at International Geodetic Conferences, one of these being now of especial interest, for his experiences at the Buda-Pesth Conference formed the subject of his talk at the banquet of the College of Engineering on December 16, 1924, and which was his last appearance before the students, for on the following day he was taken to the Evanston Hospital for treatment of an illness from which he never recovered.

As an active member of the Philosophical Society and of the Engineers Club of Washington he presented many papers on various phases of the work of the Coast Survey, and of his original investigations. He was a member of the Cosmos Club of that city and took great delight in there meeting with friends and visitors to the Capitol City.

Coming to Northwestern in 1909 to take up the duties of Director of the College of Engineering because of his firm belief in the aims and ideals which were in the minds of the

founders of the College, he has labored long and earnestly to perpetuate those aims and ideals.

Here, as in Washington, he has found time to do a prodigious amount of work other than that connected with his regular duties. Chief among these is his work as Research Associate in the Carnegie Institution, studying the laws of evaporation underlying changes in lake levels on the Great Lakes, a work on which he has spent more than a decade, and which at the time of his death required only the finishing touches of his master-hand to make it another piece of monumental work to his credit.

In 1912 he was selected by the arbitrator, Chief Justice White, to head the Commission of Engineers to survey the disputed boundary between Panama and Costa Rica, and later was a member of the Commission of Engineers and Geologists sent to study the slides at the Panama Canal. In 1915 he was appointed by the President as a member of the National Advisory Committee for Aeronautics, and as such, during the time of national need he worked with a group of scientists in Washington devising instruments for recording airplane peformance. Chief among these instruments was the Zenith Stabilizer, and for the purpose of giving this a test he was selected as one of the group who were sent on a cruiser to the Pacific Coast via the Panama Canal.

Mr. Hayford was elected a member of the National Academy of Science, one of the highest honors granted to scientists in this country, and it was one of his yearly duties and delights to attend their meetings in Washington, and he usually had some paper to present to the body, giving the results of his investigations. It was before this body that he presented much of the material contained in his volume, "Effect of Winds and of Barometric Pressures on the Great Lakes," published by the Carnegie Institution of Washington in 1922, this being as stated "a part of a much larger investigation, covering a much broader field . . . the ultimate object of the larger investigation is to obtain a much better formulation

than the engineering profession now has of the laws governing the amount of stream-flow."

In addition to those previously mentioned he was a member of the American Astronomical Society, American Society of Civil Engineers, Western Society of Engineers, and American Association for the Advancement of Science, and in which he was always an active member. In 1918 George Washington University conferred upon him the degree of Doctor of Science.

Although a scientist of the highest attainment there was probably no field in which he took keener delight than when considering the problems connected with engineering education. This was made evident in his work at the College of Engineering at Northwestern and in his participation in the work of the Society for the Promotion of Engineering Education. As a member of the latter he was strong and forceful and most highly respected and was honored by the Presidency of the Society during the years 1918–19. At the College of Engineering he constituted himself the student advisor and each semester every student was called in for rather lengthy conferences for help, advice or encouragement.

A Resolution by the Faculty of the College of Engineering of Northwestern University.

Adopted March 17, 1925.

WHEREAS: Director John F. Hayford has been the main guiding spirit of this College from its beginning in 1909 to his untimely death one week ago.

Through many years of intimate association the members of this Faculty have come to know him as a man of the following characteristics:

1. He was a believer in the ultimate triumph of truth. He was not a retailer of ready-made opinions and he did not seek to influence others by personal persuasion or by clever statement. On important problems, whether physical phenomena or of social relations, he sought to find the fundamental facts; to disentangle these facts from matters of emotion and prejudice; and to give these facts clear and forceful statement. He sought to be a leader of men by giving them better views of truth.

2. In mental work he had habits of unusual accuracy, and in industry he was almost indefatigable. In reading he formed the habit of never leaving an article with a hazy notion of its contents; he formulated a statement of its meaning when reduced to simplest terms, and he retained this meaning as a permanent addition to his stock of reliable information. The most of his researches have made successful use of data whose value and heterogeneity have appeared to other men too forbidding for systematic treatment. His studies of the data of engineering education have been of a thorough and painstaking character.

3. He was thoroughly democratic. In matters of educational policy he had opinions which he believed right because he had reached them after careful consideration of the facts. But if any question was decided in opposition to his views, he accepted the decision wholeheartedly and carried it into effect with perfect loyalty.

4. He was honest, just and generous. In college legislation he insisted that every rule should be an accurate statement of policy, and in administration, he undertook to carry out every regulation to the letter of its statement. In the absence of established fact, his opinions were always tempered with extreme generosity; he was not only generous but even prodigal in giving his time and labor to his students and to his friends; in the apportionment of funds to his faculty members he was generous, even self-sacrificing.

5. In manner of life he was modest and unassuming. In general attitude he was genuinely sociable, genial, frank, cheerful, optimistic, loyal, and in important matters aggressive; he had a keen sense of humor; he was slow in the expression of criticism, but prompt in the expression of deserved commendation.

Because of the above characteristics of Director John F. Hayford, the members of this Faculty have great confidence in the general policies which he has advocated for this College.

Resolved that: This University, this College, and its individual members have suffered a great loss in the death of our friend and director, John F. Hayford, the magnitude of which loss we have hardly begun to appreciate.

The members of this Faculty hope that means will be found not only to continue unabated our efforts in improving engineering education as heretofore directed by John F. Hay-

ford, but so to reinforce our work as to bring to fruition his complete ideal of an engineering college.

It is fitting that these statements of fact in appreciation of our first Director be made a matter of record in our minutes, be transmitted to the family of the deceased, and be transmitted to proper officials of the University for such dissemination and publicity as may be appropriate.

Secretary.

644-1-0.K

COLLEGE NOTES.

The **University of Arizona** has tried a new plan in seminar work. Instead of holding this work at a regular class hour, two meetings a month of the Student Branch of the American Institute of Electrical Engineers are held. At the first meeting seniors and juniors give papers on subjects selected by the instructor from the proceedings of the A. I. E. E. or *Electric Journal* or *General Electric Review*. These papers are followed by discussion. The student is marked on his ability as a speaker and his general bearing and attitude while on his feet and also, of course, on his subject matter which he is told to give in his own words. The seniors are given more difficult articles than the juniors.

The second meeting of the branch is devoted to business, and an outside engineer of prominence, or other professional man, addresses the students. This plan is providing quite successful.

The **Ohio State University** will hold memorial exercises in honor of Thomas Corwin Mendenhall on April 16, 1925. Addresses will be given by Dr. Ira N. Hollis, President of Worcester Polytechnic Institute; Dr. Charles Frederick Marvin, Chief of the United States Weather Bureau, Washington, D. C.; Personal Reminiscences from Dr. Elihu Thompson, Director of the Thompson Laboratory, General Electric Company.

Presentation by the Mendenhall family of a bronze replica of the portrait medallion of Dr. Mendenhall given to him by his first group of students on the fiftieth anniversary of the opening of the University, September 17, 1923. Dr. Mendenhall was an honorary member of this Society, and was President in 1898–99.

University of Pittsburgh.—F. L. Bishop, Dean of the Schools of Engineering and Mines, has just received from

President Coolidge his appointment as a member of the American delegation to the Pan-American Road Congress to be held in Buenos Aires, South America, next October. The other members are J. Walter Drake, Assistant Secretary of Commerce, *Chairman;* Charles W. Babcock, Commissioner of Highways, Minn.; Representative Wm. E. Hull of Illinois; Thos. H. MacDonald, Chief of United States Bureau of Public Roads; Frank Page, Chairman, North Carolina State Highway Commission; and G. A. Sherwell, Secretary of the Inter-American High Commission. The object is to discuss road construction in all phases, and by promoting highway development in this hemisphere, increase social and commercial bonds between Pan-American Republics.

Stevens Institute of Technology.—Alex. C. Humphreys, President of Stevens Institute of Technology, has announced that the requirements of the General Education Board and the Carnegie Corporation have been met and the total of the One Million Dollar Salary Increase Fund has been secured.

S. D. Snader, formerly Professor of Structural Engineering in South Dakota State College, has been appointed Professor of Structural Engineering in the place of Frank E. Hermanns who resigned to give his entire time to his private practice.

W. R. Halliday and S. H. Lott, formerly assistant professors in the Department of Machine Design, have been advanced to the rank of associate professor. J. C. Wegle has been made assistant professor in the same department. Professor Wegle has also been appointed acting Dean of Student Activities.

Syracuse University.—Louis Mitchell, Dean of the Lyman C. Smith College of Applied Science, Syracuse University, has been appointed to fill the vacancy in the Grade Crossing Commission occasioned by the retirement of Alexander T. Brown. By the terms of the act under which the Commission operates, the duty of naming Commissioner Brown's successor devolved upon Justices Crouch, Cheney and Edgcomb of the Supreme Court.

647-2

BOOK REVIEWS.

Power Plant Machinery. Vol. II, Details and Accessories. By W. H. JAMES, M. W. DOYLE. 1st Edition. 1924. 267 pp., 250 ill. John Wiley & Sons. $3.00.

Contents: Special Types of Reciprocating Steam Engines, Reciprocating Steam Engine Details, Turbines, Turbine Details and Accessories, Air Compressors, Pumps, Power-operated Steering and Reversing Mechanisms, Steam, Hydraulic and Pneumatic Tools, Boiler Feed Water Apparatus, Condensers, Condenser Pumps, Cooling Towers, Spray Ponds, Miscellaneous Power Plant Appliances.

The purpose of this volume is to present a few special types of engines and turbines, and to describe at length the constructional details such as frames, bearings, methods of taking up wear, packing, oiling devices.

The apparatus described is well illustrated. The authors state that the majority of illustrations are made from catalog cuts or from drawings furnished by the builders of the machines, and that much of the text is based upon descriptive matter furnished by the builders.

Elements of Steam and Gas Power Engineering. By A. A. POTTER, J. P. CALDERWOOD. 2d Ed., 1924. McGraw-Hill Book Co. 339 pp. 226 ill. $2.75.

Contents: Principal Parts of Power Plants, Units and Definitions, Steam Power Fuels and Combustion, Properties of Steam, Boilers, Boiler Auxiliaries, Piping and Boiler Room Accessories, Steam Engines, Steam Turbines, Engine and Turbine Auxiliaries, Steam Power Plant Testing, Internal Combustion Engines, Internal Combustion Engine Fuels and Gas Producers, Auxiliaries for Internal Combustion Engines, Gas Power Plant Testing, Locomotives, Automobiles, Trucks and Tractors.

The fundamental principles are clearly and concisely presented throughout. A general view of a power plant is first given and in subsequent chapters each part of the equipment is described in detail. The information presented is of a practical nature, theoretical dissertations having been avoided, thus making this a splendid book for the practical engineer and the student of power plant engineering.

W. F. W.